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Revised Groundwater Feasibility Study Report – Remedial Action Plan Interim Groundwater Remediation for Parcel H-3

Rohr, Inc. - A Collins Aerospace Company
North Campus, Chula Vista, California

March 16, 2020

AECOM

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March 16, 2020

Mr. Tom Alo
San Diego Regional Water Quality Control Board
2375 Northside Drive, Suite 100
San Diego, CA 92108-2700

Subject: Revised Feasibility Study Report – Remedial Action Plan
Interim Groundwater Remediation for Parcel H-3
Rohr, Inc. - A Collins Aerospace Company – North Campus
850 Lagoon Drive
Chula Vista, California
AECOM Project No. 60611774

Dear Mr. Alo:

On behalf of Rohr, Inc. (Rohr), a Collins Aerospace Systems Company, AECOM Technical Services, Inc. (AECOM) is pleased to provide this Revised Feasibility Study Report – Remedial Action Plan for interim groundwater remediation of Parcel H-3. Please contact Mr. Rick Siordia at 619.691.4279 or the undersigned if you have any questions.

Sincerely,

AECOM Technical Services, Inc.

PROFESSIONAL GEOLOGIST
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cc: Mr. Rick Siordia, Rohr, Inc.
Mr. Bruce Amig, UTC
Mr. Grant Carey, Porewater Solutions

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1. Introduction

On behalf of Rohr, Inc. (Rohr), a Collins Aerospace Systems Company, AECOM Technical Services, Inc. (AECOM), has prepared this Revised Feasibility Study Report – Remedial Action Plan (FS-RAP) for interim groundwater remediation of Parcel H-3 (Site), located west of the Rohr, Inc. (Rohr) North Campus Facility (North Campus). The North Campus is located at 850 Lagoon Drive in Chula Vista, California (**Figure 1**). This Revised FS-RAP incorporates revisions to the February 18, 2020 version of the FS-RAP in response to comments provided by Regional Water Quality Control Board, San Diego Region (RWQCB),dated February 25, 2020.

Parcel H-3, which is owned by the San Diego Port District (Port), is the focus of this document. Groundwater containing volatile organic compounds (VOCs), primarily trichloroethene (TCE), has migrated from the North Campus westward beneath adjacent Parcel H-3 (AECOM, 2019a; AECOM, 2019f). Pursuant to the conditions of Cleanup and Abatement Order No. 98-08 (CAO) for the North Campus, the RWQCB is requiring Rohr to implement interim groundwater remediation within Parcel H-3 prior to the start of construction for redevelopment, which is scheduled to commence in July 2020. The purpose of this report is to identify elements of the proposed interim groundwater remedy for Parcel H-3 and the plan for its implementation.

This FS-RAP report is organized as follows.

- Section 1: Introduction – Presents an overview of the objectives and the organization of this report
- Section 2: Background – Provides a description of site setting, history, and assessments
- Section 3: Physical Setting – Summarizes geology and hydrogeology around Parcel H-3
- Section 4: Nature and Extent of Contamination – Identifies the chemicals of concern and their distribution in groundwater beneath Parcel H-3
- Section 5: Conceptual Site Model (CSM) Summary – Summarizes important migration pathways, fate and transport mechanisms, and a summary of the overall CSM for Parcel H-3
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2. Background

This section presents background information including a description of Parcel H-3, the Site history, an overview of important environmental features, and a summary of previous investigations performed on Parcel H-3 and the adjacent North Campus.

2.1 Site Description

Parcel H-3 is an approximately 36.7-acre tract of land located south of the intersection of G Street and Marina Parkway in Chula Vista, California (**Figure 2**). The Site consists largely of vacant land with limited developed areas including a portion of the Chula Vista Recreational Vehicle (RV) Resort (760 Sandpiper Way) and an asphalted motorcycle riding practice area. The North Campus is located along the eastern border of Parcel H-3; the former Rohr South Campus is located to southeast; a ship repair facility and the Sweetwater Marsh National Wildlife Refuge are located to the north; and parkland is located to the west and south along the shoreline of San Diego Bay and the Chula Vista Marina.

Parcel H-3 is proposed to be redeveloped in 2020. **Figure 3** shows a conceptual layout of the proposed redevelopment of Parcel H-3. Imported fill was brought in during late 2018 to raise the grade of portions of Parcel H-3 for redevelopment activities. Prior to the fill import, the ground elevation at Parcel H-3 ranged from approximately 11 to 14 feet above mean sea level (msl). After the surcharge fill was added, the ground surface at portions of the Parcel H-3 was raised to elevations of approximately 16 to 21 feet msl.

2.2 Site History

2.2.1 Parcel H-3

Parcel H-3 occupies an area of former San Diego Bay tidelands that was subsequently filled with dredged sediments from San Diego Bay (Tetra Tech, 2015). In 1966, three warehouse buildings (Buildings 910, 911, and 912) were constructed in the fill area and subsequently leased to Rohr who occupied the buildings until 1993. Buildings 911 and 912 were within the footprint of what is now Parcel H-3. Building 910 was located just south of the Parcel H-3. Rohr operations in these buildings included material storage, material cutting and rough-finishing, and small-parts fabrication (Adrian-Brown, 1998). Rohr also operated a material storage yard and parking area in the eastern portion of Parcel H-3 during this timeframe. After Rohr vacated the buildings, they were leased to Eco Building Systems, Inc. and afterward AFS Industries, LLC (Tetra Tech, 2015). The above grade structures of the warehouse buildings were demolished in 2008 and 2009. Although the building pads are visible in aerial photograph in **Figure 2**, they were removed in 2018 prior to importing fill at Parcel H-3.

Parcel H-3 also includes a triangular parcel in the northeast corner of the Site that was previously owned by Rohr and was used for employee/contractor parking (**Figure 2**). The Port acquired ownership of that property in 2018 through an eminent domain process.

2.2.2 Adjacent North Campus

The North Campus facility began operation in 1941 for manufacturing of structural and engine components for aircraft (URS, 2016). Industrial activities have included metals casting and fabrication, and materials manufacturing, handling, assembly, and storage. Secondary activities that support the manufacturing process have included maintenance and storage of vehicles, recycling of materials, and water treatment. Operations at the North Campus have been expanded several times since the 1940s (Adrian Brown, 1998). After the fill area to the west was completed in the 1960s ("75-acre Fill Area"). **Figure 2** shows the location of the historical shoreline with respect to the current North Campus boundaries. TCE and 1,1,1-trichloroethane (1,1,1-TCA) were historically used during the manufacturing operations.

2.3 Environmental Features

As stated previously, the focus of this FS-RAP is groundwater that contains chemicals of concern (primarily VOCs such as TCE) and has migrated westward from the North Campus beneath Parcel H-3 and other downgradient areas. From this perspective, the historical environmental features relevant to this FS-RAP are located on the North Campus and include degreasers, above and below ground storage tanks, chemical processing areas, and other areas where chemicals and wastes were used or stored. Further discussion of the environmental features at the North Campus is presented in the Phase I Report by Adrian Brown (Adrian Brown, 1998), Supplemental Remediation Report for the North Campus (URS, 2015), and the Data Gap Assessment Report for the North Campus (URS, 2016).

2.4 Previous Investigations

Multiple phases of site characterization have been performed by Rohr and other entities in Parcel H-3 and the surrounding area. A general time-line of these investigations is presented below:

- 2002-2004: Cone penetrometer (CPT) groundwater investigations that included areas in Parcel H-3 (URS, 2006)
- 2005: Installation of North Campus monitoring well clusters including wells NCW-004, NCW-005, and NCW-006, which are located on Parcel H-3 (URS, 2006)
- 2015: Limited soil and groundwater investigation of Parcel H-3 and surrounding areas including soil and shallow groundwater sampling and analysis (Tetra Tech, 2015 [on behalf of the Port])
- 2015: Groundwater investigation of the area north of the Chula Vista Marina for the South Campus (Haley and Aldrich, 2015)
- 2015: Focused groundwater assessment of the Oiler Shed area and the area along the boundary with the adjacent South Campus (URS, 2016)
- 2018: Investigations consisting of membrane interface probe/hydraulic profiling tool (MiHPT) assessment and discrete-depth groundwater sampling along the western property boundary of the North Campus and north of the Chula Vista Marina; and the installation of monitoring wells in that area (AECOM, 2019b and 2019c)
- 2017: H3 Parcel Limited Soil Gas Survey (Tetra Tech, 2018)
- 2018: Active soil gas survey of Parcel H-3 (Terracon, 2019 [on behalf of RIDA)
- 2019: Investigation consisting of a MiHPT, CPT and discrete-depth sampling in Parcel H-3 and downgradient areas (AECOM, 2019a)

In addition, Rohr has conducted periodic groundwater monitoring of wells installed in Parcel H-3 and the surrounding areas as part of the groundwater monitoring programs for the North and South Campuses (AECOM, 2019d; AECOM, 2019f; Haley and Aldrich, 2017). **Table 1** summarizes construction information for these monitoring wells. **Figure 4** shows locations of monitoring wells, soil borings, soil vapor probes, and groundwater Hydropunch/monitoring well sampling conducted at Parcel H-3 and in nearby off-site areas (exclusive of the 2017 Tetra Tech soil gas sampling). The *Conceptual Site Model Report* (AECOM, 2019f) summarizes the results of the previous investigation and monitoring. Collectively, these results have established that groundwater containing VOCs has migrated offsite from the North Campus beneath Parcel H-3.

3. Physical Setting

This section presents information regarding the site setting, geology, and hydrogeology of Parcel H-3 and the surrounding area. Additional discussion of the physical setting is presented in the *Conceptual Model Report* (AECOM, 2019f)

3.1 Site Setting

Parcel H-3 is located on a peninsula of filled tidelands surrounded by the Chula Vista Marina, San Diego Bay, and the wetlands of the Sweetwater National Wildlife Refuge (**Figure 2**). The Marina and Bay are located approximately 450 feet to the south and west of Parcel H-3, respectively. Parcel H-3 is located within the La Nacíon Subunit of the Sweetwater Hydrologic Unit. Designated beneficial uses of groundwater in the La Nacíon Subunit include municipal, and industrial, and agricultural uses; however, groundwater in the Site vicinity is not suitable for these beneficial uses because of elevated total dissolved solids concentrations.

3.2 Geology

Parcel H-3 is located west of the historical high tide line and underlain by recently-imported fill and older fill consisting of dredged materials from San Diego Bay (**Figure 2**). Beneath the fill, Parcel H-3 is underlain by Holocene bay deposits, the Pleistocene Bay Point Formation, a regional clay aquitard, and the Pliocene San Diego Formation. The same geologic conditions occur at the adjacent North and South Campuses. The following discussion focuses on descriptions of the dredged fill, bay deposits, and Bay Point Formation because these features are relevant to VOC migration from the North Campus to Parcel H-3. Descriptions of the deeper regional clay aquitard and San Diego Formation are presented in other documents (URS, 2016; Haley and Aldrich, 2015).

Generalized geologic cross sections were prepared as part of the *Conceptual Model Report* (AECOM, 2019f) to illustrate the stratigraphy beneath Parcel H-3 and adjacent areas. **Figures 5** through **9** show representative cross sections that extend from the North Campus to Parcel H-3. The interpretations are based largely on the CPT and MiHPT data collected during the 2018 and 2019 investigations and lithologic logs for select monitoring wells.

3.2.1 Dredged Fill and Bay Deposits

The dredged fill materials consist of a mix of gray to dark silt, clay, sandy silt, sand, and bay mud and are generally encountered at Parcel H-3 from the pre-fill import surface grade to sea level with slightly deeper fill accumulations encountered closer to San Diego Bay. Bay deposits underlie the fill materials and generally consist of olive, gray and black silty fine-grained sand with interbeds of silt and clay typical of estuarine sediments. The base of the bay deposits varies from near sea level to approximately -15 ft msl in areas of Parcel H-3 (**Figures 5** through **9**).

3.2.2 Bay Point Formation

The Bay Point Formation underlies the bay deposits and consists of interbedded sequences of clay, silt and sand deposited in a nearshore environment. The Bay Point Formation extends to a depth of approximately 150 ft below ground surface (bgs) at the vicinity of Parcel H-3 and the North Campus (URS, 2016). Brown, olive-brown and red-brown silt and clays commonly occur at the top of the Bay Point Formation, vary in thickness from approximately five to ten feet, and are relatively continuous across most of Parcel H-3 and the North Campus. Sequences of coarser-grained units consisting predominantly of sand, silty sand, and clayey sand that are interbedded with fines, occur beneath the upper silts and clays. Several of these coarser-grained sequences are continuous across Parcel H-3 and the western portion of the North Campus. Although their thickness and depths vary, they occur at representative elevations of approximately -15 feet msl, -40 feet msl, and -70 feet msl (**Figures 5** through **9**).

3.3. Hydrogeology

The upper unconfined aquifer systems in the vicinity of the Parcel H-3 and the North and South campuses have been defined into groundwater zones for the purpose of site characterization and groundwater monitoring (URS 2016; Haley and Aldrich, 2015). Groundwater is first encountered at approximately 7 feet bgs which is the top of the A Zone. Zone A generally corresponds to the artificial fill and underlying bay deposits. Zone B corresponds to the Bay Point Formation. Zone B has been subdivided into the Upper and Lower Zone B, which correspond to the upper and lower portions of the Bay Point Formation, respectively.

The depth ranges established for the groundwater zones were based in part on well depths (AECOM, 2016; Haley and Aldrich, 2015). The bottom of Zone A was established at approximately 25 feet bgs on the North and South Campuses and 20 feet bgs in offsite areas, including Parcel H-3. The base of Upper Zone B was established at 55 feet bgs with Lower Zone B extending from this depth to the bottom of the Bay Point Formation; however, note that for Parcel H-3, the base of Upper Zone B was adjusted locally approximately 15 feet deeper to 70 feet bgs based on lithology. Groundwater occurs at depths of approximately 5 to 10 feet bgs at the North Campus and Parcel H-3.

Near the boundary of the North Campus and Parcel H-3, the fill and bay deposits are locally thin, and in some areas Zone A incorporates the upper portion of the Bay Point Formation.

3.3.1 Flow Directions and Gradients

In general, horizontal groundwater flow directions in the vicinity of Parcel H-3 are towards the west in Zone A and Upper Zone B and to the northeast (landward) in Lower Zone B (AECOM, 2019d). In December 2018, the hydraulic gradient was approximately 0.001 feet per foot in Zone A, 0.003 feet per foot in Upper Zone B, and essentially flat in Lower Zone B. In the area north of the Chula Vista Marina, the groundwater flow direction in Upper Zone B was south towards the Marina. The direction of vertical hydraulic gradients varies across Parcel H-3 and the North Campus, but in general, vertical gradients are upwards in wells located closest to the Bay and downwards in wells located inland from the Bay on the North Campus. Groundwater flow conditions in all three zones are tidally influenced.

Due to salinity, density-dependent flow conditions influence groundwater flow near San Diego Bay. Seawater intrudes landward beneath less saline groundwater in this area, and eastward (landward) equivalent freshwater head gradients occur in Lower Zone B. Salinity levels exceed those indicative of seawater (total dissolved solids of 32,000 milligrams per liter [mg/L]) in the Lower Zone B wells near San Diego Bay (NCW-007C, NCW-008C, NCW-009C), several Upper B wells in this area (NCW-007B and NCW-009B), and approach this level in NCW-006C (27,000 mg/L), located approximately 900 feet inland from the Bay (wells are shown on **Figure 4**). Total dissolved solids at most locations at Parcel H-3 are lower, generally in the range of 1,000 to 5,000 mg/L.

3.3.2 Hydraulic Conductivity

In 2019 and 2018, AECOM performed multiple pneumatic slug tests in wells located in Parcel H-3, the North Campus, and the area north of the Chula Vista Marina. A total of 13 wells were tested. The monitoring wells used were screened in 10-foot intervals, typically in coarser grained or interbedded zones. The estimated hydraulic conductivities for the two wells screened in Zone A were 15 feet per day (ft/day) and 50 ft/day. The estimated hydraulic conductivities for the wells screened in the Upper Zone B ranged from approximately 7 to 57 ft/day with an average of approximately 22 ft/day. The hydraulic conductivity of the sand zones in the Lower Zone B are expected to be similar to those of Upper Zone B because the lithologic characteristics of the sand units are similar in both zones.

The geometric mean of the estimated hydraulic conductivity from the North Campus/Parcel H-3 slug test results for Upper Zone B is approximately 18 feet per day (feet/day). For comparison, Table 14 from the Remedial Action Plan Addendum for the South Campus (Haley and Aldrich, 2015) summarizes the hydraulic conductivity estimates for the South Campus. The geometric mean of the hydraulic conductivity values for Upper Zone B for the South Campus is approximately 23 feet/day (excluding grained units, but inclusive of all estimation methods, which vary widely because most are based on grain size estimates). Both results are very similar, so the calculated hydraulic conductivities would be considered to be representative of conditions within the North Campus/Parcel H-3.

4. Nature and Extent of Contamination in Groundwater

This section summarizes the nature and extent of the chemicals of concern for Parcel H-3. Groundwater conditions are the focus of this FS-RAP, but the following summary also includes discussion of soil vapor and soil conditions at Parcel H-3. Further discussion of the nature and extent of contamination at Parcel H-3 is provided in the *Conceptual Model Report* (AECOM, 2019f)

4.1 Chemicals of Potential Concern

The chemicals of potential concern (COPCs) for Parcel H-3 are those chemicals that are present in groundwater at the North Campus, are mobile in groundwater systems, and have migrated westward beneath Parcel H-3 and to the west. Chemicals detected in groundwater at the North Campus include chlorinated VOCs primarily TCE and its breakdown products (cis-1,2-dichloroethene [cis-1,2-DCE] and vinyl chloride [VC]), 1,1,1-TCA and its breakdown products (1,1-dichloroethene [1,1-DCE] and 1,1-dichloroethane [1,1-DCA]), and 1,4-dioxane (URS, 2015; URS 2016; AECOM, 2019d).

Numerous groundwater samples have been collected at Parcel H-3 and offsite areas for VOCs, metals, and other target analytes. The constituents detected most frequently at concentrations exceeding California Maximum Contaminant Levels (MCLs) with their respective MCLs are (**Table 2**):

- TCE (MCL of 5 micrograms per liter [µg/L])
- Cis 1,2-DCE (MCL of 6 µg/L)
- VC (MCL of 0.5 µg/L)
- 1,1-DCE (MCL of 6 µg/L)
- Tetrachloroethene (PCE) (MCL of 5 µg/L)
- 1,1-DCA (MCL of 5 µg/L)
- Carbon tetrachloride (MCL of 0.5 µg/L)
- 1,2-Dichloroethane (1,2-DCA) (MCL of 0.5 µg/L)
- Trans-1,2- dichloroethane (trans 1,2-DCE) (MCL of 10 µg/L)
- Benzene (MCL of 1 µg/L)

1,4-dioxane is found in localized detections (refer to **Table 2**) within Parcel H-3 at concentrations up to 1,100 µg/L that exceed the California Division of Drinking Water (DDW) drinking water notification level (NL) of 1 microgram per liter (µg/L) and the associated Response Level of 35 µg/L. Also, localized concentrations of hexavalent chromium have been detected in only one sample at Parcel H-3 at a concentration of 31 µg/L in well NCW-004B, which is less than the MCL of 50 µg/L.

4.2 Groundwater

Of the VOCs, TCE has been detected most frequently and at the highest concentrations in groundwater at the North Campus, at Parcel H-3, and downgradient areas. The other VOCs occur with TCE and have similar distributions. Thus, the distribution of TCE in groundwater is representative of groundwater impacts in Parcel H-3. **Figures 10** through **12** show composite TCE isoconcentration contour maps for Zone A, Upper Zone B, and Lower Zone B, respectively.

Figures 13 through **15** show composite 1,4-dioxane isoconcentration contour maps for Zone A, Upper Zone B, and Lower Zone B, respectively, and indicate that the 1,4-dioxane also has a similar distribution to TCE.

4.2.1 Zone A

TCE and 1,4-dioxane were either not detected or were detected at low concentrations (e.g., less than the MCL/NL) at most samples collected from the fill material/bay deposits at Parcel H-3 (**Figures 10** and **13**). 1,4-Dioxane was reported at concentrations exceeding the NL at only 3 locations on Parcel H-3. The reported concentrations for these samples ranged from 1.1 to 2.54 µg/L (**Figure 13**), essentially meeting the NL.

Although VOC concentrations in most of the shallow samples collected at Parcel H-3 are low, TCE concentrations exceeding 1,000 µg/L were reported in samples collected at H3-DP14 (Tetra Tech, 2015), which is located near the western boundary of Parcel H-3 (**Figure 10**). TCE, however, was either non-detect or detected at low concentrations at nearby sample locations (HP-46, HP-68, HP-69, and HP-45). TCE was not detected in the co-located soil samples at the same location (Tetra Tech, 2015) or in soil gas samples collected throughout Parcel H-3. In February 2020, groundwater samples were collected at equivalent depths from a boring (HP-70) co-located with H3-DP14 to investigate the previous detections at this location. The reported TCE concentrations were substantially lower (<0.5 µg/L and 59 µg/L) than those reported for H3-DP14, confirming that the previous results were anomalous. VC was either not detected or detected at a low concentration (0.22J µg/L). The February 2020 results for HP-70 supersede the prior results for H3-DP14.

TCE concentrations (greater than 10,000 µg/L) occur within shallow sand zones in the Bay Point Formation in the northwestern portion of the North Campus (e.g., HP-57, **Figures 5** through **9**) and have migrated westward in these sand zones beneath finer grained Bay Point and fill/bay deposits at Parcel H-3. These sand units correlate to similar zones within Upper Zone B farther to the west (**Figures 5** through **9**). Although TCE concentrations are locally elevated at depths of 17 to 25 feet bgs in this area, TCE was either not detected or detected at low concentrations in co-located samples at shallower depths (**Figure 10**). For example, 22,000 µg/L of TCE was detected 19 feet bgs at HP-65, but only 0.623 µg/L was detected at 8 feet bgs. In general, TCE concentrations in shallow Zone A groundwater in this area of Parcel H-3 are low (most are below or near the MCL).

4.2.2 Upper Zone B

TCE concentrations in Upper Zone B exceed 1,000 µg/L over the majority of Parcel H-3 and in portions of the areas to the south and west (**Figure 11**). TCE concentrations exceeding 10,000 µg/L occur downgradient of the former TCE/1,1,1-TCA above ground storage tank at the North Campus (east of HP-21) and extend offsite to Parcel H-3. Similar TCE plumes occur downgradient of HP-18, and, at lower concentrations, downgradient of the Oiler Shed Area on the south side of the North Campus. 1,4-Dioxane concentrations have a similar distribution but at much lower concentrations and only exceed the RL of 35 µg/L in a localized area in the northeast portion of Parcel H-3 (**Figure 14**). VOC migration from the North Campus occurs primary in laterally-continuous, coarser-grained sequences at representative depths of approximately -15 feet msl and -40 feet msl that are separated vertically by finer grained units (**Figures 5** through **9**).

TCE degradation products (cis-1,2-DCE and VC) are present in most samples at concentrations that exceed MCLs (AECOM, 2019f). The concentrations of cis-1,2-DCE generally range between 100 and 1,000 µg/L with higher concentrations detected in the northeastern portion of the Parcel H-3 (downgradient of the former TCE/1,1,1-TCA above ground storage tank) and in the vicinity of the Chula Vista Marina. The cis-1,2-DCE concentrations in wells along the San Diego Bay (NCW-007, NCW-008, NCW-009) exceed 100 µg/L. VC concentrations show similar trends across Parcel H-3, but at lower concentrations (1 to 1,000 µg/L at most locations).

4.2.3 Lower Zone B

TCE concentrations locally exceed 15,000 µg/L on-site at the North Campus (HP-68), and concentrations exceeding 1,000 µg/L extend south into the eastern portion of Parcel H-3 (**Figure 12**). Lower concentrations (10 to 100 µg/L) occur farther south toward the Chula Vista Marina. 1,4-Dioxane detections are limited (**Figure 15**). Saline water that has intruded into the Lower Zone B sands may minimize direct migration of the VOC plumes in Lower Zone B towards San Diego Bay and the Chula Vista Marina.

4.3 Soil Gas

Two soil gas surveys have been conducted at the Parcel H-3 as reported in *H3 Parcel Limited Soil Gas Survey* (Tetra Tech, 2018) and *Limited Soil Gas Investigation* (Terracon, 2019). Tetra Tech collected 25 soil gas samples from the Parcel H3 and 5 additional off-site samples in December 2017. Samples were collected between 5 and 10 feet bgs. Terracon collected soil gas samples from probes installed at depths between five and 10 feet bgs at 26 locations on Parcel H-3 in November 2018 (Terracon, 2019). The following VOCs were detected:

- carbon disulfide
- 4-methyl-2-pentanone
- Benzene
- Ethylbenzene
- Toluene
- m,p-Xylene
- o-Xylene
- Chloroform
- 1,1,1-TCA
- TCE
- PCE

The reported VOC concentrations for detentions in soil gas were less than commercial risk screening levels (Terracon, 2019; Tetra Tech, 2018).

4.4 Soil

In 2015, on behalf of the Port, Tetra Tech advanced 20 borings on Parcel H-3, eight borings in the offsite areas west of Parcel H-3, and two borings in the offsite area north of the Marina in 2015 and submitted soil samples from these borings for analysis for VOCs and other analytes (Tetra Tech, 2015). VOCs were detected in 27 of 104 soil samples at concentrations less than their respective RSLs in all samples. TCE was detected in five samples at concentrations ranging from 21 micrograms per kilogram (µg/kg) to 730 µg/kg, well below the RSL of 6,000 µg/kg. The TCE detections are associated with the deepest samples (14 to 15 feet bgs) at H3-DP1, H3-DP2, H3-DP3, H3-DP4, which are located near the western property boundary of the North Campus (**Figure 4**). These samples were likely collected from the saturated zone because the depth to groundwater in this area is less than 10 feet bgs. The TCE detected in soil at these locations appears to be associated with dissolved-phase TCE.

5. Conceptual Site Model Summary

This section discusses important contaminant fate and transport mechanisms for contaminants in groundwater beneath Parcel H-3 and an overall summary of the CSM for groundwater. Additional discussion of the CSM is provided in the *Conceptual Model Report* (AECOM, 2019f).

5.1 Contaminant Migration Pathways

The releases of chlorinated VOCs and 1,4-dioxane at the North Campus have migrated with groundwater flow to the west onto Parcel H-3 and other offsite areas. Environmental features that appear to be sources of offsite VOC migration include the former TCE/1,1,1-TCA above ground storage tank, historical releases in the Oiler Shed area, and possibly former vapor degreasers or other features in the northwestern portion of the North Campus (**Figure 2**).

In general, the artificial fill and shallow Bay Point Formation are fine-grained with relatively low hydraulic conductivity and consequently, limited lateral dissolved-phase migration has occurred in these shallow materials at the North Campus (URS, 2016). However, where releases have migrated vertically into underlying sand zones, and where sand zones are interconnected, lateral VOC migration in groundwater has occurred offsite from the North Campus to Parcel H-3 and the Chula Vista Marina/San Diego Bay. Laterally-continuous, coarser-grained sequences are present at representative elevations of approximately -15 feet msl and -40 feet msl in Upper Zone B and -70 feet msl in Lower Zone B at the North Campus and extend offsite beneath Parcel H-3 (**Figures 5** through **9**). Offsite VOC migration occurs in each of these units with the highest concentrations present in Upper Zone B. VOC concentrations reported in Zone A and Lower Zone B groundwater (shallower fill/bay deposits and the deeper aquifer, respectively) at Parcel H-3 are substantially lower.

Vertical groundwater gradients may affect VOC and 1,4-dioxane migration between these coarser zones especially where intervening finer grained units are thin or absent. Vertical gradients are variable in the FS-RAP area but generally shift from downward at well clusters located on the North Campus to upwards at clusters located near the San Diego Bay. Near the Bay, sea water intrudes below less saline water, causing upward vertical gradients in the overlying freshwater zones. This process may also cause upward migration of the plumes near the Bay.

The VOC and 1,4-dioxane plumes within in Upper Zone B in Parcel H-3 extend to the Chula Vista Marina (**Figure 11** and **14**). In addition, the VOC plume in Lower Zone B has migrated towards the marina (**Figure 12**). The influence of tidal fluctuations, which cause lateral reversals in flow direction near the shore, will enhance mixing and dispersion of the plumes in these areas. This enhanced mixing/dispersion will cause attenuation of the plume concentrations, particularly in the near-shore areas.

5.2 Abiotic and Biological Degradation

Biological degradation and other natural attenuation process such as mixing and dispersion can result in mass removal and stability of VOC plumes. Biological degradation byproducts of TCE via reductive dechlorination processes include cis-1,2-DCE and VC. In Upper Zone B, the historical concentrations of cis-1,2-DCE have generally ranged between 100 µg/L and 10,000 µg/L (AECOM, 2019f). Historical VC concentrations have ranged from 1 to 1,000 µg/L at most locations (AECOM, 2019f). Several wells at Parcel H-3 have trends of increasing cis-1,2-DCE and VC and decreasing TCE concentrations (NCW-006A, NCW-007A, NCW-8B) (AECOM, 2019d). These trends and the widespread presence of VC comingled with cis-1,2-DCE provide supporting evidence of ongoing TCE mass removal through reductive dechlorination in Parcel H-3 and other offsite areas. Detections of 1,1-DCE, a byproduct of abiotic degradation of 1,1,1-TCA, are also widespread at Parcel H-3 and offsite areas (AECOM, 2019f). Based on the presence of these degradation products, reductive dechlorination and/or abiotic degradation are important mass removal mechanisms for chlorinated ethenes and ethane in groundwater beneath the Parcel H-3 area.

As shown on **Figures 13** and **14**, 1,4-dioxane concentrations are elevated in a localized area of Zones A and UB in the northwest portion of the North Campus and decrease substantially to the west (downgradient) on Parcel H-3. In Zone A, 1,4-dioxane concentrations at most sample locations are less than or only slightly exceed NL. In Upper Zone B, 1,4-dioxane concentrations at three locations exceed the RL with substantially lower concentrations at locations farther west and south toward San Diego Bay and Chula Vista Marina. At most locations closest to the bay, the 1,4-dioxane concentrations are less than the NL. The overall reduction of 1,4-dioxane concentrations downgradient of the North Campus indicates that natural attenuation may be occurring due to mixing/dilution and possibly biological processes.

5.3 Mass Storage and Back Diffusion in Fine Grained Units

The processes of forward- and back-diffusion of VOCs into and then out of fine-grained soils have been shown to sustain VOC concentrations in aquifers at levels well above cleanup criteria for long periods of time at sites where fine-grained clay or silt is present (Chapman and Parker, 2005; Parker et al., 2008; Kavanaugh et al., 2013; Carey et al., 2014; Carey et al., 2015). Site-specific evaluations of back-diffusion and mass storage have been prepared for release areas at the North and South Campuses (AECOM, 2019c; Haley and Aldrich, 2015). While these investigations have focused on source areas, the same processes occur within plumes. At Parcel H-3, dissolved-phase TCE concentrations exceed 10,000 µg/L in the coarser-grained sequences where plumes are migrating. These sequences include interbedded fine-grained intervals that are underlain and overlain by relatively thick fine-grained zones. During plume migration at these concentrations, VOC concentration gradients between the impacted sand units drives forward diffusion of VOCs into the fine-grained layers, effectively storing VOC mass in these layers. As concentrations in the sand units decline because of natural attenuation process or active remediation efforts, slow back diffusion from the VOC mass stored in these fine-grained layers can generate sustained VOC concentrations that can prolong remediation time frames on the order of decades to centuries.

5.4 Volatilization

VOC concentrations in shallow Zone A groundwater at Parcel H-3 are relatively low, generally less than MCLs. Higher concentrations of these VOCs are detected in Upper Zone B, moreover they are separated from the shallower groundwater zone by saturated fine-grained units (fill and bay deposits), which inhibit volatilization/migration of VOCs to the vadose zone at Parcel H-3. This is consistent with the results of the soil gas surveys conducted at Parcel H-3 where the VOCs that were detected did not exceed applicable human health risk screening criteria (Terracon, 2019; Tetra Tech, 2018).

5.5 Conceptual Site Model Summary

Groundwater containing TCE, other VOCs, and 1,4-dioxane is present within the aquifer systems underlying Parcel H-3 and extends towards the Chula Vista Marina. Seawater intrudes below less saline water in the western area of the plume, causing upward vertical gradients and upward VOC plume migration in the overlying freshwater zones. Based on the presence of degradation products, reductive dechlorination and abiotic degradation are important mass removal mechanisms for chlorinated ethenes and ethane in groundwater; however, given the abundant presence of silt/clay layers in contact with the VOC plumes, back diffusion of VOC from these silts/clays along flow paths is expected to sustain VOC concentrations and extend remedial time frames. **Figure 16** shows a schematic illustration of this CSM.

6. Human Health Risk Assessment Summary

This section summarizes the findings of the HHRA for Parcel H-3. Additional details of HHRA are presented in the report titled *Human Health Risk Assessment, Parcel H-3* (AECOM, 2019h). The scope of the HHRA was limited to an assessment of potential health risks posed to future receptors consistent with the planned land use of Parcel H-3.

6.1 Constituents and Media of Concern

As summarized in **Section 5.0**, VOCs have migrated from the North Campus to Parcel H-3 and therefore the primary media of concern for Parcel H-3 is groundwater containing VOCs. Secondary impacted media would include saturated soil in contact with VOCs in groundwater and soil gas containing VOCs that has volatilized from shallow groundwater. Potential human and ecological risks for areas downgradient of Parcel H-3 will be evaluated as part of a future site-wide risk assessment for the North Campus.

6.2 Potential Receptors

Parcel H-3 is proposed to be redeveloped as a hotel/convention center space with an attached pool/water park area. Based the proposed Parcel H-3 redevelopment activities, potential future receptors at Parcel H-3 will include:

- Construction worker
- Landscape worker (including utility worker)
- Commercial worker
- Hotel guest/ recreational user

6.3 Exposure Pathways

Groundwater is not used locally for irrigation, domestic, or industrial uses because of elevated concentrations of total dissolved solids. Thus, exposures for direct groundwater uses are incomplete for all receptors. The potentially complete human health risk exposure pathways for Parcel H-3 are summarized below and illustrated in **Figure 17**.

Construction Worker and Landscape/Utility Worker:

- Incidental ingestion of saturated subsurface soil
- Dermal contact with saturated subsurface soil
- Inhalation of vapors in a trench from groundwater
- Dermal contact with groundwater in a trench

Commercial Worker:

- Inhalation of vapors in indoor air emanating from subsurface media (saturated subsurface soil and groundwater) due to vapor intrusion into future on-site buildings.

Hotel Guest/Recreational User:

- Inhalation of vapors in indoor air emanating from subsurface media (saturated subsurface soil and groundwater) due to vapor intrusion into future on-site buildings.

6.4 Exposure Assessment

The vapor intrusion pathway is complete for future commercial workers (employees of the Convention Center, Hotel, and Water Park) and for future hotel guests. Previous vapor intrusion evaluations (Tetra Tech, 2018; Terracon, 2019) concluded that the vapor intrusion pathway does not pose unacceptable health hazard or cancer risk for commercial and residential receptors. During preparation of the HHRA, however, these previous evaluation results were reviewed to confirm that the conclusions reached in the previous reports are still valid in light of the Department of Toxic Substances Control's (DTSC's) current vapor intrusion guidance. For the evaluation, the results of the Terracon (2019) Limited Soil Gas Investigation were used, because the vapor probes were advanced in locations of the future convention center and water park buildings and the resulting data more accurately reflect the exposure conditions for the future building receptors at Parcel H-3. The exposure pathways for construction worker/landscape/utility worker are considered complete and potentially significant and were evaluated further. Exposure point concentrations (EPCs) were developed for these pathways using VOC concentrations in saturated soil and shallow groundwater (data for samples collected to a maximum depth of 15 feet bgs). The HHRA considered the redevelopment plans to segregate Parcel H-3 into two exposure areas: Parcel H-3 East (hotel conference center area) and Parcel H-3 West (water park area) and therefore, separate EPCs were developed for each exposure area (**Figure 18**).

6.5 HHRA Summary

As part of the preparation of the HHRA, the results of those previous evaluations were reviewed to confirm that the conclusions reached in the previous reports are still valid in light of DTSC's current vapor intrusion guidance. Cumulative cancer risks and noncancer hazards for commercial worker and hotel guest exposures to soil gas through the vapor intrusion to indoor air pathway are below the DTSC target risk level of 1×10^{-5} and target health goal of 1. These results confirm the conclusions of the previous vapor intrusion investigations that no unacceptable health risk is anticipated for commercial workers or hotel guests of the future buildings through the vapor intrusion pathway, even under the conservative use of the maximum detected soil gas concentrations combined with the default residential attenuation factor of 0.03 to estimate indoor air concentrations.

For the Parcel H-3 West (Water Park Area), construction worker and landscaper exposures based on maximum detected concentrations in saturated subsurface soil and groundwater in the Water Park exposure area resulted in noncancer hazard indices (HIs) that exceeded the target health goal of 1 and cancer risks that exceeded the acceptable risk level range of 1×10^{-6} to 1×10^{-4}. Cancer risks were driven almost entirely by exposures to VC and TCE in groundwater. Exposure to soil alone does not pose unacceptable risk to construction workers or landscapers in this area. The reported risks and hazards in the Water Park exposure area are driven by a single set of sample results at location H3-DP14 at the 10-foot depth interval near the northwestern property boundary. As described in **Section 4.2.1**, the February 2020 sampling results confirm that the concentrations of VOCs measured in H3-DP14 are anomalous, and the groundwater results from HP-70 should supersede the prior concentrations measured in H3-DP14. These results also indicate that concentrations in shallow groundwater at HP-70 are below the health-based remediation goals for the construction and landscape workers (discussed further below) and thus pose no unacceptable health hazard or cancer risk for construction and landscape workers. As such, the risk assessment results for Parcel H-3 West now reflect results less than the noncancer target health goal of 1 and fall within the acceptable cancer risk level range (1×10^{-6} to 1×10^{-4}).

For the Parcel H-3 East (Hotel Conference Center Area), construction and landscape worker exposures based on maximum detected concentrations in saturated subsurface soil and shallow groundwater resulted in noncancer HIs that were equal to or below the target health goal of 1 and cancer risks within the acceptable risk level range of 1 x 10^{-6} to 1 x 10^{-4}. For both receptors, cancer risks exceeded the DTSC target risk level of 1 x 10^{-5} and were driven almost entirely by exposures to VC in groundwater. Saturated soil and shallow groundwater do not exceed the target health goal, and cancer risks are within acceptable risk level range (1 x 10^{-6} to 1 x 10^{-4}); however, the estimated cancer risks exceed the DTSC threshold risk level of 1 x 10^{-5}. Cancer risks were driven almost entirely by exposures to VC in groundwater. The maximum concentration of VC of 7.1 μg/L was measured at H3-DP1. The only other detection of VC in Parcel H-3 East was much lower (0.39 μg/L at DP-465).

Health-based remediation goals for the primary risk drivers in groundwater (TCE and VC) were calculated to be protective of construction workers (VC: 3 ug/L and TCE: 34 ug/L) and landscape workers (VC: 1 ug/L and TCE: 18 ug/L). These health-based remediation goals were exceeded at only two locations across the entire Parcel H-3. In the Convention Center exposure area, VC at H3-DP1 exceeded the remediation goal for both construction worker and landscaper receptors and will be addressed with a Groundwater Management Plan (GMP; see **Sections 7.4.4** and **8.4**). In the Water Park exposure area, health-based remediation goals for VC and TCE were exceeded at H3-DP14 for both the construction and landscaper worker receptors. However, VOCs measured in H3-DP14 are anomalous, and the groundwater results for samples collected from HP-70 supersede the prior results for H3-DP14. TCE and VC were not detected in the shallow (water table) sample collected at HP-70 and thus, the TCE and VC in groundwater do not pose an unacceptable health hazard or cancer risk for construction and landscape workers in this area.

No other exceedances of health-based remediation goals were noted. Taking into account the conservative assumptions inherent in the risk assessment process coupled with the fact that exposures are unlikely to occur at a single location across the exposure area, particularly for the duration and frequency assumed in the exposure assumption, concentrations of site-related chemicals measured in saturated subsurface soil (to a depth of 15 feet bgs) and shallow groundwater actual health risks for construction worker and landscaper exposures are expected to be much lower.

7. Evaluation of Interim Remedial Alternatives

This section presents a feasibility study (FS) evaluation of the potential interim remedial alternatives for VOCs in groundwater that could be implemented prior to construction of the planned redevelopment of Parcel H-3. The FS supports the objective to identify a remedial technology that can be technically and economically implemented at the Site to reduce the VOC concentrations in groundwater and to support attainment of future site-wide cleanup requirements of the North Campus. The following sections describe the approach, assumptions, and components of the evaluated alternatives along with the rationale for selection of the preferred alternative for implementation.

7.1 Site-Wide Cleanup Goals for North Campus

As summarized in the Alternative Cleanup Levels and Revised Background Soil and Groundwater reports (AECOM, 2019g, AECOM, 2019e), remediating TCE and other VOCs to background conditions at the North Campus/Parcel H-3 is impracticable and alternative cleanup levels are proposed for Parcel H-3/North Campus that are protective of human health and the beneficial uses of groundwater. The beneficial uses of groundwater include municipal and domestic supply, as designated in the Water Quality Control Plan for the San Diego Basin. The applicable cleanup criteria consistent with these situations are Drinking Water MCLs (**Section 4.1**). An MCL has not been established for 1,4-dioxane, but DDW has established an NL for 1,4-dioxane. The DDW requires water purveyors to notify its customers and take other actions if NLs are exceeded in a drinking water source (a production well for example) and recommends removing a drinking source from service if the RL is exceeded. For 1,4-dioxane, the NL is 1 μg/L and corresponds to a $3x10^{-6}$ lifetime cancer risk for drinking water consumption. The RWQCB has specified that the cleanup goal for 1,4-dioxane for North Campus correspond to the NL.

7.2 Remedial Action Objectives for Interim Remediation of Parcel H-3

Rohr proposes the following remedial action objectives for interim groundwater remediation of Parcel H-3:

- Protection of human health
- Reducing the flux of VOCs migrating from the North Campus to Parcel H-3
- Removal of VOC mass from groundwater beneath Parcel H-3
- The interim remedy should work in concert with the future site-wide remedy for the North Campus and adjacent off-site areas to help achieve the overall cleanup goal of achieving MCLs

Although some access may be available in select areas of Parcel H-3 for remediation after construction is complete, for the purpose of this evaluation of interim remedial alternatives, Rohr has assumed that Parcel H-3 will be largely inaccessible for remediation after construction of the site improvements begins.

7.3 Target Areas for Interim Remediation

Rohr proposes to target injections and the interim remedial action in the interpreted area of Parcel H-3 within the plume where TCE concentrations exceed 5,000 µg/L in groundwater within Upper Zone B. The rationale for this approach is as follows:

- This portion of the TCE plume encompasses the primary migration pathways from the North Campus westward beneath Parcel H-3 (**Figure 11**)
- This area of the plume corresponds to a large portion of Parcel H-3
- In general, other VOCs that occur at elevated concentrations coincide with the distribution of TCE (AECOM, 2019f)

Remediation within this area will limit further migration of TCE and other VOCs onto and through Parcel H-3, reduce VOC groundwater concentrations in groundwater within Parcel H-3 by removing contaminant mass, and support on-going biological degradation of TCE and other VOCs in groundwater. Within Parcel H-3, TCE concentrations exceeding 5,000 µg/L in Zone A groundwater only occur near property boundary of the North Campus and coincide with similar concentrations in Upper Zone B (**Figures 10** and **11**); therefore, interim remediation of Upper Zone B in this area will extend into Zone A to also address Zone A groundwater. In Lower Zone B, TCE concentrations that exceed 5,000 µg/L occur primarily on the North Campus (**Figure 12**). Upper Zone B remediation will reduce VOC mass in groundwater and support monitored natural attenuation (MNA) of Lower Zone B groundwater within Parcel H-3.

7.4 Screening of Remedial Technologies

A screening evaluation of applicable groundwater remediation technologies was performed initially to determine which groundwater technologies to carry forward for the development of remedial alternatives. The screening process considered the following factors:

- Effectiveness (mass removal and effective treatment life)
- Implementability (ability to implement prior to start of construction at Parcel H-3)
- Compatibility with subsurface conditions
- Compatibility with the planned redevelopment of Parcel H-3
- Cost

The following technologies are effective, implementable, compatible with future site conditions, have reasonable costs and were retained for the development of remedial alternatives:

- Enhanced Insitu Bioremediation (EISB)
- Combined Insitu Chemical Reduction (ISCR) and EISB
- MNA
- Engineered controls

Table 3 provides a summary of the technology screening. A few common technologies for treating VOC plumes in groundwater include in-situ chemical oxidation (ISCO) and groundwater pump and treat. Implementation of ISCO has difficulties, such as the relatively short lifespan of ISCO amendments (weeks to months) and the need for multiple rounds of injection. Groundwater extraction and aboveground treatment was eliminated during the screening process because of the uncertainty of achieving capture of the COC plumes under a tidally-influenced environment. In addition, the piping network necessary to convey pumped groundwater to a central treatment system building would be incompatible with the planned redevelopment of Parcel H-3.

7.4.1 Enhanced In Situ Bioremediation (EISB)

EISB is a technology that uses the natural metabolic process of microorganisms to degrade chlorinated ethene (e.g., TCE) and chlorinated ethane (e.g., TCA) compounds under anaerobic conditions in the presence of a suitable electron donor. This technology can be combined with bioaugmentation, which is the practice of adding a commercially prepared microbial culture to facilitate the biodegradation of the compounds of interest. The mechanism generally results in the sequential reduction of the chlorinated compounds to ethene or ethane.

The use of short-term fermentable donors like lactate as well as longer-lasting donors like emulsified vegetable oil (EVO) to provide a source of carbon to enhance the reductive dechlorination of TCE is a generally accepted in-situ remediation technology, and would be applicable to Parcel H-3 based on the successful results of a bioremediation pilot test conducted on the South Campus near former Building 42 (Haley and Aldrich, 2015). During this pilot test, EVO and lactate were injected together to provide both a readily available and long-lasting electron donor. The pilot test demonstrated that EISB was successful in reducing TCE concentrations by creating anaerobic and reducing conditions and providing the necessary degrader microorganisms in groundwater. TCE half-lives within the pilot test treatment area are one to two orders of magnitude lower than other areas of the South Campus (Haley and Aldrich, 2015), demonstrating the effectiveness of this groundwater remedy in shortening the remedial time frame. Enhanced anaerobic conditions would also support the biodegradation of TCE and other chlorinated VOCs that are detected at Parcel H-3.

For Parcel H-3, EISB products would be injected by direct push technology in a grid pattern or in the form of multiple treatment zones across the target areas for interim remediation.

7.4.2 Combined In Situ Chemical Reduction and Enhanced In Situ Bioremediation (ISCR)

ISCR is a process by which contaminants are degraded or chemically transformed through the addition of a reducing compound, such as zero valent iron (ZVI). ZVI-mediated degradation of TCE can be achieved by direct abiotic breakdown, as ZVI provides electrons to substitute chlorine atoms in the chlorinated molecule. In combined ISCR/EISB, the abiotic degradation processes are combined with another pathway that utilizes ZVI as an electron donor for bacteria-mediated degradation, and in this case, a carbon source amendment, such as EVO, is added. ISCR/EISB is applicable to a wide variety of contaminants, including chlorinated ethenes and ethanes. Typically, ISCR/EISB amendments remain reactive in the subsurface for a longer duration than typical EISB amendments (e.g., up to five years for ISCR/EISB vs one year for EISB products). During a bench scale testing of this technology in the oiler shed area on North Campus, an ISCR product containing a combination of ZVI and EVO was shown to be effective in reducing the TCE and other VOCs (AECOM, 2019i).

For plume treatment applications, ISCR/EISB products are typically applied as permeable reactive barriers (PRBs) through soil mixing or injection. For Parcel H-3, ISCR/EISB products containing a combination of controlled-release carbon, ZVI, and nutrients, would be injected to form multiple PRBs across the target area for interim remediation.

The effectiveness of PRBs rely on groundwater flow to transport contaminants through the PRB for treatment. Therefore, in addition to the ISCR/EISB barriers, EVO would be injected in a grid pattern within the inferred 10,000 µg/L TCE contours to reduce contaminant mass directly within these areas and to address potential uncertainties with groundwater flow in the higher concentration portions of the TCE plume.

7.4.3 Monitored Natural Attenuation

MNA is the combination of biological degradation and other natural attenuation process such as mixing and dispersion and can result in mass removal and stability of VOC plumes. As described in **Section 5.2**, several wells at Parcel H-3 have trends of increasing concentrations of TCE degradation byproducts (cis-1,2-DCE and VC) with decreasing TCE concentrations. These trends and the widespread presence of VC comingled with cis-1,2-DCE provide supporting evidence of ongoing TCE mass removal through reductive dechlorination in Parcel H-3 and other offsite areas. Based on the presence of these degradation products, reductive dechlorination and/or abiotic degradation are important mass removal mechanisms for chlorinated ethenes and ethanes in groundwater beneath the Parcel H-3 area. Natural attenuation of 1,4-dioxane may occur by mixing, dispersion and possibly biological processes. The overall reduction in 1,4-dioxane concentrations downgradient of the North Campus indicates that MNA for 1,4-dioxane may be an effective remedy for Parcel H-3.

MNA would be implemented by monitoring existing and new monitoring wells to demonstrate plume stability and/or declining VOC/1,4-dioxane concentrations within and near Parcel H-3. There are currently 3 triple-nested well clusters (NCW-004, NCW-005, and NCW-006) located within Parcel H-3 (**Figure 4**). The NCW-004 and NCW-006 well clusters will be destroyed immediately prior to redevelopment and will be replaced after redevelopment is completed and additional monitoring wells will be installed for MNA and performance monitoring after grading for the redevelopment is complete. Well cluster NCW-005, which will remain in place, and the other existing monitoring wells that border Parcel H-3 will also serve as monitoring points (see **Section 8.2.2**). MNA would be implemented in combination with active remediation within the target area for interim remediation and/or on its own for the remaining areas of Parcel H-3.

7.4.4 Engineered Controls

The engineered controls applicable to Parcel H-3 would include a GMP (**Section 8.4**) to mitigate exposure to VOCs in groundwater in those areas of the site where the HHRA (**Section 6.5**) identified potential health risks for construction and landscape workers due to VOC concentrations in shallow groundwater. Best practices for groundwater management would include segregation and testing of groundwater prior to developing specific areas where workers could come into contact with groundwater to confirm the presence of chemicals and identify specific engineered and institutional controls to deploy to be protective of human health.

7.5 Development and Evaluation of Alternatives

The retained technologies listed above were used to develop two alternatives for interim remediation of Parcel H-3:

- Alternative 1 - EISB, MNA, and Engineered Controls
- Alternative 2 - ISCR/EISB, MNA, and Engineered Controls

The alternatives were evaluated using the following criteria:

- Effectiveness: the ability to remove contaminant mass and establish decreasing concentration trends and/or reduce VOC concentrations
- Implementability: the ability to construct and reliably implement the alternative over a period of 3 to 4 months prior to the start of construction of Parcel H-3 redevelopment
- Overall protection of human health: ability to be protective of human health, both during implementation and after remediation activities are complete
- Costs: capital construction and maintenance costs

The following sections discuss the evaluation for each alternative, **Appendix A** includes feasibility level (Class III) cost estimates for each alternative, and **Table 4** provides an overall summary of the alternatives evaluation.

7.5.1 Alternative 1 – EISB, MNA, and Engineered Controls

Alternative 1 uses EISB to target TCE concentrations within the 5,000 µg/L concentration contour in Zone A and Upper Zone B. In these active treatment areas, EISB would be implemented in a grid formation (**Figure 19**) using direct-push injections in order to further facilitate TCE and daughter product degradation. For this alternative, it is assumed that direct-push injection of both a carbon source and microbial amendments would be used to distribute amendment within the targeted area. Due to the schedule for redevelopment; however, the site would only be accessible for one EISB injection event.

MNA would be implemented in Zone A, the portions of Upper Zone B outside of the direct injection locations, and in Lower Zone B groundwater zones where COCs exceed cleanup criteria. Additional engineered controls in the form of GMPs (**Section 8.4**) would be used to protect construction and landscape workers from exposure to COCs during property development.

Effectiveness

The effectiveness of the EISB and MNA remedy would be moderate, given that the effectiveness of EISB in removing TCE from groundwater has been proven in the bioremediation pilot test and at many other sites in California. The pilot test performed at the South Campus demonstrated that EISB was successful in reducing the contaminant mass of chlorinated compounds by creating anaerobic conditions in groundwater and facilitating ongoing natural attenuation. This is manifested in the widespread distribution of the TCE degradation daughter products cis-1,2-DCE and vinyl chloride, which indicate anaerobic reductive dechlorination of chlorinated compounds. However, redevelopment activities will limit the EISB program to one injection event. Therefore, the amount of donor able to be injected during a single event will likely be insufficient to overcome the relatively high sulfate concentrations (a competing electron acceptor) and ongoing back diffusion from low permeability materials within the expected 1-year to 2-year lifecycle of EVO. This remedy would be implemented based on data from the South Campus bioremediation pilot test and EISB program to refine the full-scale implementation. In addition, this alternative may not sufficiently control the migration of VOCs from the North Campus to Parcel H-3 unless a similar remedy is considered for upgradient areas on the North Campus.

Implementability

The ability to implement this alternative would be low. Limitations to materials and contractor equipment occur when EISB is applied over larger areas. The time necessary to inject amendments can become extended beyond what is practicable for larger injection areas due to the presence of clays and silts. Finer grained soils slow down injection rates and can limit amendment distribution. Therefore, the primary focus of injections will be in the more permeable/sandy soils. However, even with this focus, the completing all required injection points within the 3 to 4 months of field time available before the start of redevelopment would be challenging with available contractor equipment and materials.

Overall Protection of Human Health and the Environment

The overall protectiveness of human health of this alternative would be moderate when combined with engineered controls such as a GMP. The concentrations of VOCs in groundwater would be reduced substantially within the EISB treatment areas and over the longer term in areas included in the MNA program, although the extent of these longer-term effects may be limited. The risk of exposure shallow groundwater would be mitigated further by implementation of GMPs, which would be the focus of engineered controls.

Cost

The cost to implement EISB and MNA would be moderate. The total estimated cost of Alternative 1 is approximately $9.3 million (Class III estimate). A detailed cost estimate is provided in **Appendix A**. The cost basis includes the following assumptions:

- Injection spacing based on the bioremediation pilot test at South Campus radius of influence (ROI) of 22.5 feet
- Approximately 951 EISB injection points in Zone A and Upper Zone B groundwater zones
- The EISB injection program in active treatment areas would last approximately three to four months

7.5.2 Alternative 2 – ISCR/EISB, MNA, and Engineered Controls

Alternative 2 uses a combination of ISCR and EISB to be injected in areas exceeding 5,000 µg/L TCE to reduce mass in Parcel H-3 and limiting transport offsite in Zone A and Upper Zone B. PRBs would be installed in Zone A (along the upgradient/eastern boundary with North Campus) and in three other locations within Upper Zone B (**Figure 20**) using direct-push injections of a combination of an ISCR amendment, such as Sulfidated Micro-Scale Zero Valent Iron (S-MZVI®) and an EVO-type product. The treatment barriers would be spaced at horizontal distances of approximately 750 feet or less, based on an estimated 5-year reactive life for ZVI and a groundwater velocity of 150 feet per year (calculated using an average hydraulic conductivity [22 feet per day], estimated effective porosity of 0.16, and hydraulic gradient of 0.003 [refer to **Section 3.0**]). EVO would be used to stimulate biotic degradation while the ZVI component of the ISCR amendment would provide ongoing remediation over a longer timeframe (estimated to be at least 5 years). EVO would also be injected within the 10,000 µg/L TCE contours to facilitate biotic degradation in areas with higher concentrations.

MNA would be implemented in the Zone A, the portions of Upper Zone B outside of the direct injection locations, and in Lower Zone B groundwater zones where COCs exceed cleanup criteria. Additional engineered controls in the form of GMPs would be used to protect construction and landscape workers from exposure to COCs during property development.

Effectiveness

The effectiveness of the ISCR/EISB and MNA remedy would be moderate to high, given that the effectiveness of EISB and ISCR in removing targeted COCs from groundwater has been proven in the South Campus bioremediation pilot test, the North Campus bench scale test, and at many sites. The longevity of the ISCR component of the remedy is designed to address the dissolved phase groundwater contamination within the 5-year lifespan of the PRBs based on current understanding of groundwater flow velocities and directions at the site.

Implementability

The ability to implement this alternative would be moderate. Limitations to materials and contractor equipment occur when ISCR/EISB is applied over larger areas. The materials and equipment necessary to implement ISCR/EISB at this scale are available. There are no foreseeable barriers to implementing ISCR/EISB within the 3 to 4-month timeframe.

Overall Protection of Human Health and the Environment

The overall protectiveness of human health of this alternative would be moderate to high when combined with engineered controls. COCs in Zone A and Upper Zone B groundwater would be reduced substantially downgradient of the ISCR/EISB PRB and over the longer term in areas included in the MNA program. Similarly, COCs in Lower Zone B groundwater would be reduced over time in the areas laterally and vertically downgradient of the ISCR/EISB PRBs and in areas included in the MNA program. The risk of exposure to shallow groundwater impacts would be mitigated further by implementation of GMPs, which would be the focus of engineered controls.

Cost

The cost to implement ISCR/EISB and MNA would be moderate. The total estimated cost of Alternative 2 is approximately $7.8 million (Class III estimate). A detailed cost estimate is provided in **Appendix A**. The cost basis includes the following assumptions:

- Injection spacing for the EISB is based on the bioremediation pilot test at South Campus ROI of 22.5 feet
- Approximately 269 EISB injection points in Zone A and Upper Zone B groundwater zones in the 10,000 µg/L TCE contour
- The Upper Zone B PRBs are positioned to intercept contaminant plumes on Parcel H-3 within the estimated 5-year lifecycle of the S-MZVI® and EVO mix
- ROI for the S-MZVI® and EVO mix is estimated at 8 feet to 10 feet, based on experience at similar sites. Injection points are spaced 15-feet on center to allow for overlap between injection points
- Approximately 168 ISCR/EISB injection points
- The EISB/ISCR injection program in active treatment areas would take approximately three to four months to complete

7.6 Recommended Remedial Alternative

Alternative 2 is recommended for the Zone A and Upper Zone B groundwater zones because of the effectiveness of ISCR/EISB approach (demonstrated by the North Campus bench scale test, and the documented effectiveness of ISCR/EISB treatment at similar sites). In addition, the implementation of ISCR/EISB treatment within the available timeframe (three to four months) is more feasible than an approach using more than twice as many injection points focused solely on EISB (Alternative 1), and the proposed ISCR/EISB treatment barriers will have a longer lifespan than EISB injections. In addition, the recommended alternative will incorporate MNA for 1,4-dioxane and for VOCs outside of the direct injection locations to address long-term management of the residual VOC and 1,4-dioxane plumes. Engineered controls such as GMPs will be implemented to protect construction and landscape workers from exposure to VOCs in shallow groundwater (**Section 8.4**).

8. Groundwater Remedial Action Plan

As described in the FS in **Section 7.0**, the objective of the recommended remedial alternative is to reduce the migration of VOCs onto Parcel H-3 from the North Campus and to reduce VOC mass in groundwater beneath Parcel H-3. The recommended remedial alternative to address these goals includes a combination of ISCR/EISB PRBs installed in transects across to the VOC plume and the injection of EISB amendments in a grid pattern within portions of Parcel H-3 where higher VOC concentrations occur (**Figure 20**). The ISCR/EISB remedy for VOCs will be combined with MNA for 1,4-dioxane within Parcel H-3 and for VOCs in areas of Parcel H-3 outside of the active treatment area.

8.1 ISCR/EISB Remedy Overview

ISCR/EISB will reduce chlorinated VOC concentrations and establish decreasing concentration trends through time in Zone A and Upper Zone B groundwater. The ISCR/EISB remedy will include the injection of ISCR amendment and EVO to form treatment transects into the two targeted groundwater zones through direct-push injections to create PRBs that will reduce contaminant concentrations and limit migration. In addition, EVO and a microbial consortium will be injected within the 10,000 µg/L TCE contours to reduce contaminant mass. MNA would be implemented by monitoring existing and new monitoring wells to demonstrate plume stability and/or declining VOC and 1,4-dioxane concentrations within and near Parcel H-3. Additional description of the full-scale ISCR/EISB remedy is provided in the following sections.

8.1.1 Target Treatment Area

Four ISCR/EISB PRBs are proposed (**Figure 20**). The treatment areas are primarily based on TCE concentrations that exceed 5,000 µg/L. The barrier located near the property boundary of North Campus (Barrier 1) will target both the Zone A and Upper Zone B groundwater to limit migration of TCE and other chlorinated VOCs from North Campus onto Parcel H-3. Barrier 2, located in the center of Parcel H-3, will target Upper Zone B groundwater and intercept the 10,000 µg/L TCE isoconcentration contours within the anticipated 5-year travel time of groundwater. Barriers 3 and 4 are located near the downgradient boundaries of Parcel H-3 to target Upper Zone B groundwater as a further means of limiting migration of VOCs from Parcel H-3.

In addition, EVO and a microbial consortium will also be injected in a grid pattern within the 10,000 µg/L TCE contours to further reduce contaminant mass within Parcel H-3.

8.1.2 Amendment Application Methods

<u>PRBs</u>

The ISCR/EISB amendments will be introduced into the treatment areas using single-use (direct-push) injection methodology. Amendments may be injected at additional locations based on conditions encountered during field activities. An estimated 168 injection points (**Figure 20**) will be advanced as part of Alternative 2 with 8 additional points within Barrier 2 to address conflicts with deep redevelopment piles (**Figure 21**) for a total of 176 PRB points.

The spacing between the proposed ISCR injection locations is approximately 15 feet. This spacing is based on an assumed distribution of 8 feet to 10 feet for the ISCR. Based on vendor recommendations, the ROI will be achieved by combining a micro-scale ZVI product with EVO and makeup water to form a volume of solution equivalent to 25% of the effective pore volume within the PRB. Based on current understanding of groundwater flow at the site of 150 feet per day, residence time within the PRBs is expected to be 39 days for an assumed 8-foot ROI, which exceeds the necessary 28-day time recommended by vendors. Note that injection spacing for ISCR/EISB locations may be modified in the field by up to 20 percent based on field observations (refer to **Section 8.2.2**).

The treatment intervals are based on current understanding of each of the targeted treatment groundwater zones. Treatment intervals for each of the PRBs are as follows:

- Barrier 1 – 15 feet to 60 feet bgs
- Barrier 2 – 25 feet to 70 feet bgs
- Barrier 3 – 25 feet to 70 feet bgs
- Barrier 4 – 25 feet to 70 feet bgs

The amendment will be applied in a top to bottom approach at 2-foot to 5-foot intervals at each injection location. This approach may be modified dependent on field conditions and actual results. Multiple injection points may be manifolded to an injection rig equipped with pressure and flow gauges for each injection line.

Note that the current development design includes the use of deep cast-in-place piles beneath the future structures. In areas where these piles could substantially reduce the effective treatment width of the PRBs, an additional eight offset injection points will be installed to increase the effective width of the treatment zone, increasing the total planned ISCR injection points to 176 locations. **Figure 21** shows the locations of the offset injection points.

<u>EVO Injection Grids</u>

For the injection grids within the 10,000 µg/L TCE contours, EVO solution will be introduced into the treatment area using single-use (direct-push) injection methodology. Amendments may be injected at additional locations based on conditions encountered during field activities. An estimated 269 injection locations will be advanced to target Upper Zone B groundwater. For injection locations near the boundary of the North Campus the injections will also target sand zones within the lower portion of Zone A. The spacing between the injection points will be approximately 40 feet to allow for some overlap, based on the 22.5-foot ROI observed during the EISB pilot test at South Campus. At each injection interval, a microbial solution will also be injected using a “donut” approach (i.e., surrounding the culture with anaerobic water) to protect the culture during injection. The amendment will be applied in a top to bottom approach at 2-foot to 5-foot intervals at each injection location. This approach may be modified dependent on field conditions and actual results. Multiple injection points may be manifolded to an injection rig equipped with pressure and flow gauges for each injection line.

8.1.3 Recommended Amendments and Quantity

As discussed in **Section 7.5.2**, the ISCR/EISB remedy includes injecting S-MZVI®, EVO, and a microbial consortium to stimulate a combination of abiotic and reductive transformation of VOCs. The following subsections summarize the types of carbon substrates, microbial consortia, and contingency materials to be used for promoting COC biodegradation at the Site.

Amendment

The recommended amendments for the ISCR/EISB are a combination of ISCR amendment and EVO. The ISCR amendment proposed for these PRBs contains S-MZVI® with a typical lifecycle of 5 or more years. The sulfidation of the ZVI can enhance the reactivity by limiting the reaction of ZVI with water. EVO is typically a microemulsion of food-grade carbon with a typical lifecycle of 1 year to 2 years. The benefits of this approach are as follows:

- The ISCR/EISB amendment stimulates both the biotic and abiotic degradation pathways for TCE
- The ISCR/EISB amendment has an expected lifecycle of 5 or more years, making it suitable for a PRB application
- The combination of ZVI and EVO effectively reduced COC concentrations in the North Campus bench scale testing. COC concentrations were also effectively reduced following the South Campus bioremediation pilot test, which supports the effectiveness of the EISB component of the remedy
- EVO will be used in the PRBs to enhance distribution of the S-MZVI®, reduce concentrations of sulfate (a competing electron acceptor), and stimulate the reductive dechlorination pathway. Within the 10,000 µg/L TCE contours, EVO will be used to stimulate biotic degradation of COCs and reduce contaminant mass
- EVO, S-MZVI®, and bioaugmentation cultures are included in the list of authorized Injection Material Amendments of the General Waste Discharge Requirements (WDR) permit issued by the RWQCB (Order No. R9-2008-0081)
- ISCR and EVO have been successfully used at numerous sites

The amount of ISCR amendment and EVO needed to conservatively provide in-situ VOC treatment for a period of approximately 5 years and 1 year, respectively, for injection locations was estimated using the following:

- Substrate calculation spreadsheet “The Substrate Estimating Tool for Enhanced Anaerobic Bioremediation of Chlorinated Solvents” (Parsons, 2010)
- Vendor calculation spreadsheets for a typical ISCR product, S-MZVI®
- Site-specific hydrogeologic data and geochemical parameters (e.g., dissolved oxygen, nitrate, iron, manganese, and sulfate concentrations)
- The size of the treatment area
- Stoichiometric demands of contaminant concentrations

The calculated quantities for the injection event are approximately 115,000 pounds of ISCR amendment and 408,453 pounds of EVO as shown in **Table 5**. The carbon substrate calculations were based on vendor analysis of VOC, sulfate, nitrate, and dissolved oxygen concentrations in groundwater**.** The ISCR amendment and EVO substrate spreadsheets are included in **Appendix B**.

Microbial Consortia

A commercial DHC culture KB-1™ or equivalent, will be used to enhance the EISB component of the remedy. These cultures are included on part of the General WDR and would be applied to target a concentration in the aquifer of 10^6 cells per liter of DHC.

8.2 ISCR/EISB Remedy Implementation

The following describes ISCR/EISB remedy implementation activities.

8.2.1 Pre-Field Activities

The following activities will be conducted prior to implementing groundwater remediation.

- Permits will be obtained from the DEH for the proposed performance monitoring wells and injection borings

- An application to enroll the Site under the San Diego Region Order No. R9-2008-0081 to implement ISCR/EISB activities will be prepared. As required by the RWQCB this will include obtaining a Waste Discharge Requirements (WDR) by completing a Report of Waste Discharge (ROWD), which includes submitting a Standard Form 200 application form, a proposed monitoring plan consistent with this RAP Addendum, and a technical report documenting that the proposed discharge will meet the requirements of Order No. R9-2008-0081
- A California-licensed land surveyor will locate and mark proposed monitoring well and injection locations
- A geophysical survey will be conducted at each of the proposed well and injection locations to identify subsurface utilities and subsurface features. Proposed well and injection locations will be adjusted in the field where conflicts are identified
- Dig-Alert will be notified at least 48 hours prior to starting remediation activities
- Access agreements will be obtained if required
- Work notifications will be made in accordance with RWQCB and DEH permits
- The existing Site-specific Health and Safety Plan (HASP) will be updated

It should be noted that permitting, planning, and surveying activities where practical have already commenced in preparation for starting injections in accordance with the proposed schedule (see **Section 8.6**). However, initial site visits have also indicated that a separate injection event for several of the proposed injection points that are in currently active City streets with multiple subsurface utilities may have to be completed after development starts and these utilities have been removed as safe access in/around the utilities may not be possible at this time. Other factors such as trenches and/or stockpiles of either soil, asphalt, or concrete that have been placed on the property may also prevent access to some of the proposed injection points. As these points are identified, alternative locations or rescheduling these injections will be discussed with the RWQCB.

8.2.2 Installation of Performance Monitoring Wells

New and existing monitoring wells will be used for performance monitoring of the ISCR/EISB remedy. As described previously, there are currently three nested well clusters (NCW-004, NCW-005, and NCW-006) located within Parcel H-3 (**Figure 20**). The NCW-005 well cluster will be protected in place. NCW-004 and NCW-006 are in conflict with the planned redevelopment and will be destroyed prior to commencement of grading operations for redevelopment; however, the wells will remain in place during injection activities and will be used for initial evaluation of amendment distribution and performance monitoring. The six wells in the NCW-004 and NCW-006 well clusters will be replaced after site grading is complete and access is available for well installation.

Immediately prior to the start of field injection activities, Rohr will install 13 temporary groundwater monitoring wells (consisting of six single- and seven dual-screened wells) within the treatment area to evaluate amendment distribution and initial performance monitoring (**Figure 20**). These temporary wells will be destroyed prior to the start of grading operations for the redevelopment of Parcel H-3. **Table 6** summarizes the construction details for the temporary wells.

In addition, Rohr proposes to install an additional 33 permanent groundwater monitoring wells and the six replacement wells for NCW-004 and NCW-006 to assess overall treatment performance, where accessible (**Figure 20**). The upgradient ISCR/EISB barrier (Barrier 1) will be located on the North Campus, so it will be feasible to install performance monitoring wells prior to installation of the barrier and to establish baseline conditions. Given the construction schedule for Parcel H-3 and the conflicts with future structures, however, opportunities for the installation of permanent wells for the downgradient barriers and elsewhere within Parcel H-3 are limited. During a January 17, 2020 meeting between Rohr, RWQCB, the Port and the redevelopment team, guidelines for potential locations were discussed and approved. The new permanent monitoring wells within Parcel H-3 will not be installed until grading of the new redevelopment and the final design of facility layout is complete and safe access is provided by the redevelopment contractor. **Table 6** summarizes the construction details for the proposed permanent wells.

Well Installation Procedures

The procedures that will be followed during well construction are summarized below:

- Prior to drilling, the locations will be cleared to at least 5 feet bgs using hand auger techniques. Grab soil samples will be collected and analyzed with a photoionization detector (PID)
- All wells will be constructed in accordance with *California Well Standards* (California Department of Water Resources) using sonic or a hollow-stem auger (HSA) drilling methods by a C-57 licensed driller. Actual well construction will be determined based upon soil core lithology observed in the field. All soil cores will be logged using a modified Unified Soil Classification System (USCS) methods by a geologist working under the direction of a State of California professional geologist. Head space samples will be collected and analyzed with a PID every 10 feet or at every lithology change
- Permanent monitoring well construction will consist of the following:
  - Wells will be 4-inch in diameter and constructed with Schedule 40 polyvinyl chloride (PVC)
  - Wells will be screened within the target treatment depths (ranging from 15 to 70 ft bgs) with screen lengths that are 5 to 15 feet. Well specific screen lengths and depths will be determined by lithology logged in the field and available historical data, in particular from the 2018/2019 CPT/MiHPT investigation borings advanced within Parcel H-3 (AECOM, 2019f)
  - The filter pack will consist of graded silica sand
  - A minimum of 1-foot of transition sand will separate the filter pack from the sanitary seal
  - Bentonite transition seal will be installed above the transition sand and will be a minimum of 3 feet in thickness. The seal will be allowed to hydrate a minimum of 30 minutes prior to installing the annular seal
  - Annular seal will consist of nominally 90% Type II Portland cement and 10% bentonite
  - Final well completion will be determined based upon the specific location of each well which will follow industry best practices to protect the well and minimize interference with redevelopment activities. The locations and reference points for all permanent monitoring wells will be surveyed by a licensed surveyor
  - Upon completion of well construction, each well will be developed prior to baseline sampling
- Temporary monitoring wells will be constructed similar to above but will be completed as 2-inch diameter monitoring wells

8.2.3 Field Injection Activities

Amendments will be injected into groundwater using direct-push methods at approximately 445 EVO and ISCR/EISB locations. Injections will be conducted in order of the shallowest injection depth to the deepest injection depth interval at each location (i.e., top to bottom approach). This order may be reversed if it proves too difficult for the force of the direct-push rig to push deeper after stopping. Injections will be performed at 2-foot to 5-foot intervals within the more permeable soil identified in each zone. Injections will not be performed where permeable soil is not present and substrate delivery is not physically possible.

If an individual injection location includes treatment of Zone A and Upper Zone B groundwater, then the injections will proceed until amendments have been delivered to each injection interval in both zones. As stated above, ideally this will occur from the top injection interval to the bottom injection interval. In cases where only one groundwater zone has been designated for treatment, the injection intervals will be adjusted accordingly. If refusal is encountered at a particular injection interval, then the volume of amendment for that interval may be injected at one or more subsequent intervals or an alternate step-out location may be installed.

Potable water from one or more locally available fire hydrants will be used to make the amendment solution at the targeted dosage during the injection process. Both the ISCR amendment and the EVO will be delivered as liquids and will be mixed with potable water to form a solution. Potable water and the amendments will be prepared on site using a mechanical mixing system. Amendments will be injected at an approximate flow rate of 4 gallons per minute using vertical tooling equipped with backflow preventers. For the PRBs, the ISCR and EVO amendments will be combined into a single solution and injected.

If a microbial culture is used, the injection rods will be advanced to each targeted depth, the injection will begin with the delivery of approximately half of the amendment solution. This will be followed by the microbial consortium, which will be surrounded by protective layers of anoxic water. The microbial consortia being used to reduce COCs require anoxic conditions to thrive. The anoxic water will be prepared in a tank by removing dissolved oxygen from potable water by purging with nitrogen gas, adding ISCR amendment, or adding an oxygen scavenger (like KB-1 Primer™) until the dissolved oxygen level is reduced to less than 0.5 mg/L. The remaining EVO solution will then complete the injection at that targeted depth.

As discussed in **Section 8.1.3**, approximately 115,000 pounds of ISCR amendment and 408,453 pounds of EVO will be mixed with approximately 2,000,000 gallons of potable water as shown on **Table 5**. The actual volume of mixing water and the total injection volume will be adjusted based on field observations. For example, if field observations indicate that it is not feasible to achieve the prescribed injection volume at a particular injection location or depth due to low permeability soils, less dilution water will be used to inject the required volume of amendment in a reasonable time. Additional injection points to deliver the remaining amendment will be added if there are no obstructions or safety hazards present.

Multiple locations will be injected simultaneously to reduce field time. Amendment dilution ratios, the volumes injected into each well, injection flow rates, and pressure applied to the injection point will be monitored and recorded during the injections. This will include:

- Periodic measurements of injection pressures, liquid flow rates and water levels in existing observation wells
- Records of injection start times and injection completion for each interval
- Records of total amendment addition for each lift and boring

8.2.2 Confirmation of Amendment Distribution

During implementation of the remedy, sampling and field observations will be used to confirm the distribution of the ICSR and EVO amendments. Soil borings will be advanced to confirm the distribution of the ISCR amendment within the PRBs, and monitoring wells will be sampled to confirm the distribution of EVO within the injection grids. The results of these assessments will be used to optimize injection point spacing at subsequent locations.

An estimated 14 soil boings will be advanced within the PRBs to confirm the distribution of the ISCR amendments (**Figure 20**). At each of these locations, continuous soil cores will be collected within the presumed injection radius of influence, logged for lithology (as described above) and visually assessed for the presence of ZVI within the targeted treatment zone. In addition, up to three groundwater samples will be collected per borehole using a Hydropunch™ sampler, and the samples will be assessed for indications of the amendment (redox conditions, pH, conductivity, color, cloudiness). The samples will also be analyzed at an offsite laboratory for total organic carbon and total iron concentrations to quantitatively assess the distribution of both the organic and the ZVI components of the ISCR amendment. The final number and placement of confirmation borings may be optimized based on field observations during the injection program. **Table 7** summarizes details of the soil boring and sample depths.

Two permanent monitoring wells (NCW-004B and NCW-005B), and seven temporary monitoring wells will be located within the footprint of the EVO injection grids (**Figure 20**). EVO injection points will be advanced near each of these wells within the presumed injection radius of influence, and after the injection is complete, groundwater samples will be collected and analyzed. The samples will be evaluated in the field for changes in pH, redox conditions, conductivity, color, and turbidity relative to baseline conditions, which may indicate the presence of the amendment, and submitted to an offsite laboratory for total organic carbon analysis. **Table 6** summarizes the temporary well construction details.

8.3 Groundwater Monitoring

Groundwater monitoring will be conducted to document baseline conditions, to evaluate performance of the ISCR/EVO remedy, to assess WDR compliance, and to monitor for MNA and site-wide groundwater conditions. **Table 8** summarizes the monitoring objectives for each well. **Table 9** summarizes the monitoring frequencies and analytical parameters for the groundwater baseline, performance monitoring, WDR monitoring, and the MNA monitoring programs. **Figure 20** shows the well locations.

The existing monitoring wells located within Parcel H-3 (NCW-004, NCW-005 and NCW-006 clusters) along with the temporary monitoring wells installed prior to remedy implementation will be sampled to establish baseline conditions and on a quarterly basis until redevelopment activities start (**Table 9**); at which point the wells within Parcel H-3, except for well cluster NCW-005 which will be protected in place, will be destroyed. Monitoring of the existing wells located outside of the redevelopment area will continue during the redevelopment. After site grading is complete and the site is accessible for well installation, the new and replacement monitoring wells will be installed within Parcel H-3, and monitoring of these wells will resume in accordance with the approved monitoring plan.

Existing and proposed monitoring wells will be used to assess MNA of 1,4-dioxane (**Table 9**). **Figures 13** and **15** show the locations of wells that will be monitored for 1,4-dioxane in Zone A and Lower Zone B, respectively. **Figure 22** shows the locations of wells that will be monitored for 1,4-dioxane in Upper Zone B.

8.4 Engineered Management Strategies

The HHRA identified one isolated area within Parcel H-3 where VOC concentrations in shallow groundwater may pose unacceptable risks to construction or landscape workers (**Section 6.5**). In the Convention Center exposure area, VC at H3-DP1 exceeded the remediation goal for both construction worker and landscaper receptors. VOC concentrations are expected to decline over time at this location as the remedy is implemented and through natural attenuation processes. Engineered management strategies will be implemented to reduce exposures to these areas until the VOC concentrations decline to acceptable levels.

Potential risks to future construction and landscape workers will be managed through implementation of a GMP. The GMP will be prepared to protect workers from possible contact with chemicals in groundwater that may be generated by dewatering for subsurface construction, including excavation and utility placement. The GMP will describe appropriate dewatering control and discharge requirements, including a description of the engineered controls necessary to minimize worker contact with groundwater, and the treatment technologies and methods required to meet applicable discharge criteria specified in project permits and approvals. The GMP plan will be submitted for RWQCB review and approval.

8.5 Reporting

The following reporting will be associated with the implementation of the interim remedy:

- Well construction completion reports will be submitted to the DEH within 60 days of installation in accordance with DEH requirements
- Monitoring reports will be prepared and submitted to the RWQCB in accordance with the approved WDR
- Performance monitoring reports will be prepared and submitted in accordance with a newly developed and approved groundwater monitoring/performance monitoring plan. These reports may be combined with the WDR reports if feasible
- Following installation of the ISCR/EISB barriers, a report will be submitted to document the implementation activities. The report will include well logs, quantities and types of amendments injected to the subsurface, the sequence of amendment injections, monitoring results, and supporting data and records

8.6 Schedule

Implementation of the proposed interim remedy will commence immediately upon approval of this plan. Pre-field activities and permitting are expected to take one month, and the ISCR/EISB injections are expected to require three months to complete. **Figure 23** summarizes the proposed project schedule.

Rohr's goal is to complete the injection work on Parcel H-3 prior to July 1, when construction of the Parcel H-3 improvements is scheduled to commence. However, as noted in **Section 8.2.1**, a limited number of proposed injection points may need to be completed after development has started as part of a separate injection mobilization.

9. Limitations

Services performed by AECOM for this evaluation have been conducted in a manner consistent with the level of care and skill ordinarily exercised by other professional consultants under similar circumstances. No other representations are either expressed or implied, and no warranty or guarantee is included or intended in this report. Opinions relating to environmental and geological are based on limited data and actual conditions may vary from those encountered at the times and locations where the data were obtained, despite the use of due professional care.

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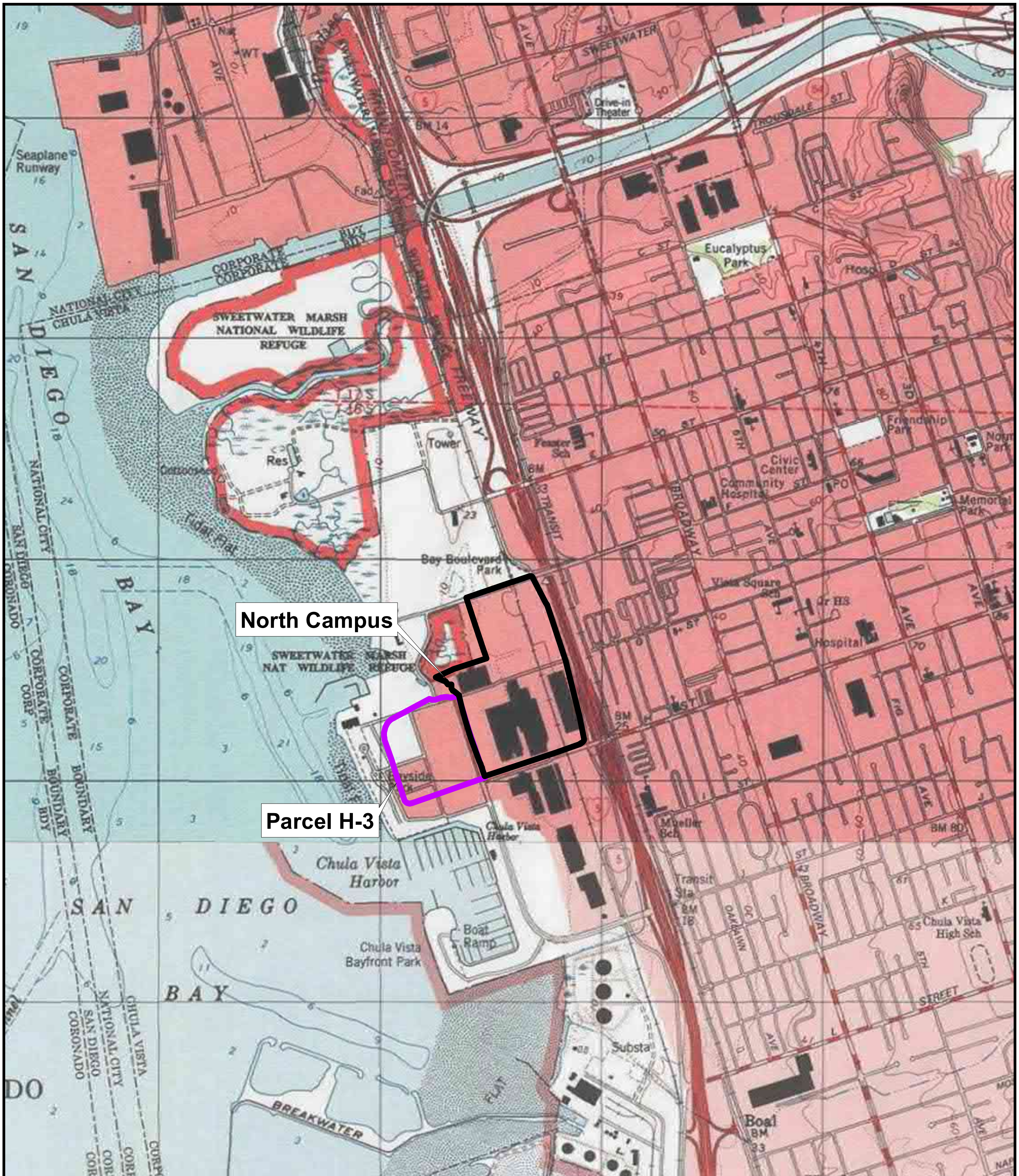
Figures



SOURCES: Following Layers From USGS:
National City (1975) and El Centro (1976) 7.5min quads

SITE LOCATION MAP
ROHR
CHULA VISTA, CALIFORNIA

AECOM

1000 0 1000 2000 Feet

SCALE: 1" = 2000' (1:24,000)
SCALE CORRECT WHEN PRINTED AT 8.5X11

CREATED BY: DA	DATE: 8/13/2019	FIG. NO:
PM: RS	PROJ. NO: 60611775.01	1

Path: P:_6040\60400790_UTC_Rohr\900-CAD-GIS\920 GIS\mxd\2019\H3 Report\Fig_1_SiteLocation.mxd, daniel.arellano, 8/13/2019, 4:53:49 PM


V1 DEGREASER
OILER SHED
V3 DEGREASER
North Campus
TCA/TCE AST
ALLEDGED SEEPAGE PITS
V2 DEGREASER
H Street
South Campus
SWEETWATER MARSH NATIONAL WILDLIFE REFUGE F & G STREET MARSH
Marina Parkway
Triangle Parcel
Proposed Site Redevelopment
Sandpiper Way
Motorcycle Training Area
Sandpiper Way
G Street
Bayside Parkway
RV Resort Park
Quay Ave
CHULA VISTA MARINA
LEGEND
V2 DEGREASER Historical Site Feature
CSM Report Coverage
Parcel H-3 Boundary
North Campus Property Boundary
South Campus Property
Approximate Location of Shoreline Based on Photograph Review
1944
1960
SOURCES:
Aerial Imagery (SANDAG 2017).
SITE PLAN
ROHR - CHULA VISTA
AECOM
150 0 150 300 Feet
SCALE: 1" = 150' (1:1,800)
SCALE CORRECT WHEN PRINTED AT 22X34
CREATED BY: DA
DATE: 9/19/2019
PM: RS
PROJ. NO: 60611775.01
FIG. NO:
2

LEGEND

- Parcel H-3 Boundary
- North Campus Property
- South Campus Property

SOURCES:
Aerial Imagery (SANDAG 2017).

SITE PLAN AND FUTURE REDEVELOPMENT
ROHR - CHULA VISTA

100 0 100 200 Feet
SCALE: 1" = 100' (1:1,200)
SCALE CORRECT WHEN PRINTED AT 22X34

AECOM

CREATED BY: DA	DATE: 9/6/2019	FIG. NO:
PM: RS	PROJ. NO: 60611775.01	3

LEGEND

- Rohr Property Boundary
- Parcel H3 Boundary
- Groundwater Monitoring Wells

2019 Investigation Points

- CPT/MIP Boring
- Hydropunch Boring

2018 Investigation Data Points

- MiHpt

2015 AECOM Investigations

- CPT-MIP Boring Locations

2015 Haley & Aldrich Hydropunch Boring Locations

- Hydropunch Boring

Historic Wells & Borings

- CPT

2015 TetraTech Investigation Data Points

- Boring Location

2018 Terracon Vapor Data Points

- Vapor Data Points

2016-2018 Haley & Aldrich Investigation Data Points

- Boring Locations

SOURCES:
Wells, Borings, CPT Locations (URS/AECOM 1999-2018); Vapor Data Points (Terracon 2018); Boring Locations (TetraTech 2015); Shallow Boring Data (Haley & Aldrich 2016-2018); Aerial Imagery (SANDAG 2017).

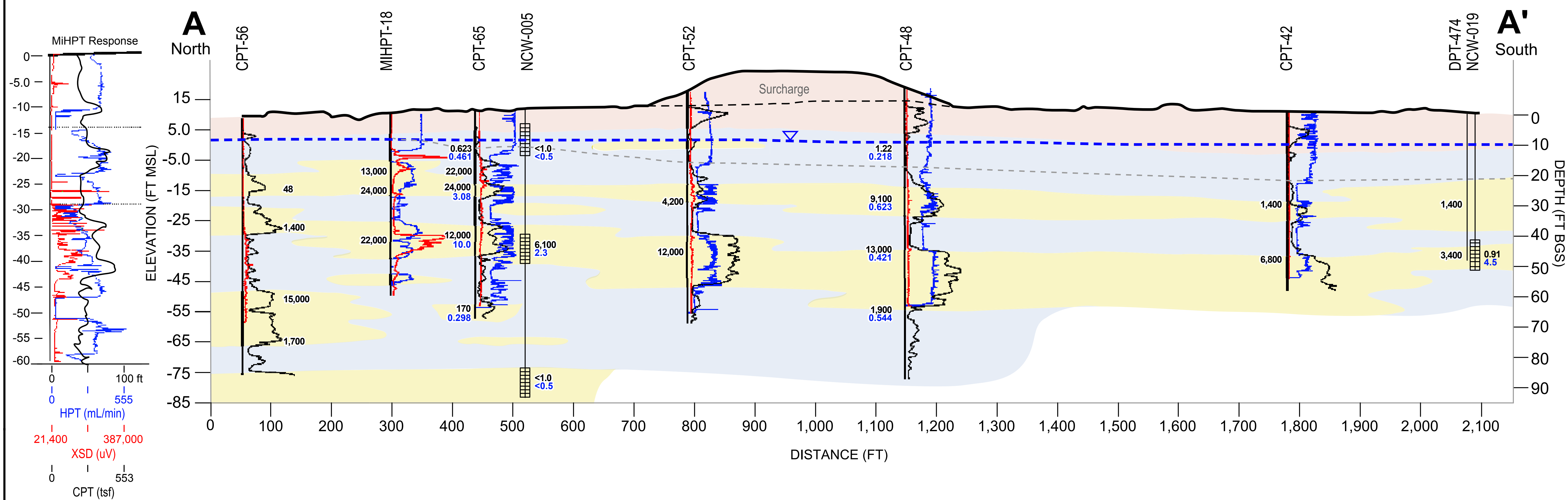
H-3 PARCEL AND VICINITY INVESTIGATION POINTS
ROHR - CHULA VISTA

AECOM

100 0 100 200 Feet

SCALE: 1" = 100' (1:1,200)
SCALE CORRECT WHEN PRINTED AT 22X34

CREATED BY: DA	DATE: 9/6/2019	FIG. NO:
PM: RS	PROJ. NO: 60611775.01	4



Legend

HPT (mL/min)	FT= Feet
XSD (uV)	BGS = Below ground surface
CPT (tsf)	MSL= Mean Sea Level
Surcharge, new fill	XSD = Halogen Specific Detector Response
Fill/ Re-worked Native	EC= Electrical Conductivity
Coarser grained (sand, silty sand, clayey sand)	CPT= Cone Resistance, qt
Finer grained (clay and silt)	HPT Flow = Hydraulic Pressure Flow
Inferred Base of Bay Deposits	mL/min = micrograms per liter
Approximate Groundwater Elevation (July 2019)	uV = microvolts
Screened Interval	tsf = ton per square feet
	mS/cm = milliSiemens per centimeter
	ug/L = micrograms per liter
	19,000 ug/L = trichloroethene sample result
	300 ug/L = 1,4-Dioxane sample result
	Elevations surveyed in NAVD88

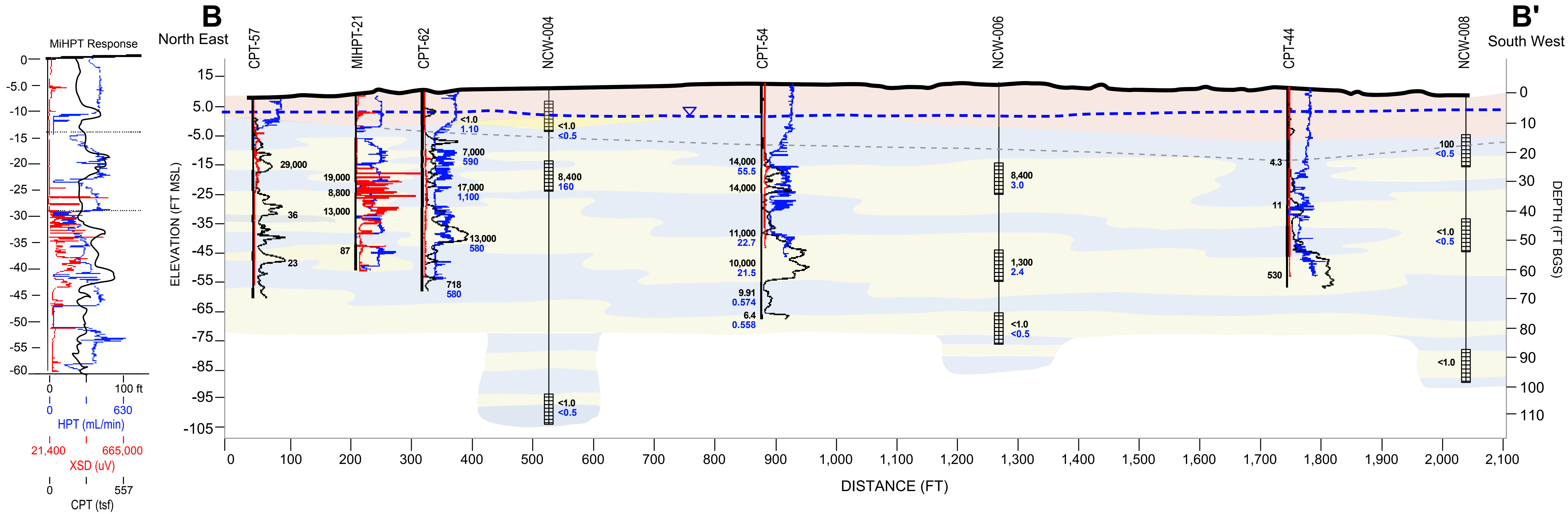
Geologic Cross-Section A-A'

AECOM

0 100' 200'

Vertical Exaggeration 5:1

CREATED BY: DB	DATE: 09/09/2019	FIG. NO:
PM: RS	PROJ. NO: 60545231	5



Legend

- HPT (mL/min)
- XSD (uV)
- CPT (tsf)
- Fill/ Re-worked Native
- Coarser grained (sand, silty sand, clayey sand)
- Finer grained (clay and silt)
- Inferred Base of Bay Deposits
- Approximate Groundwater Elevation (July 2019)
- Screened Interval

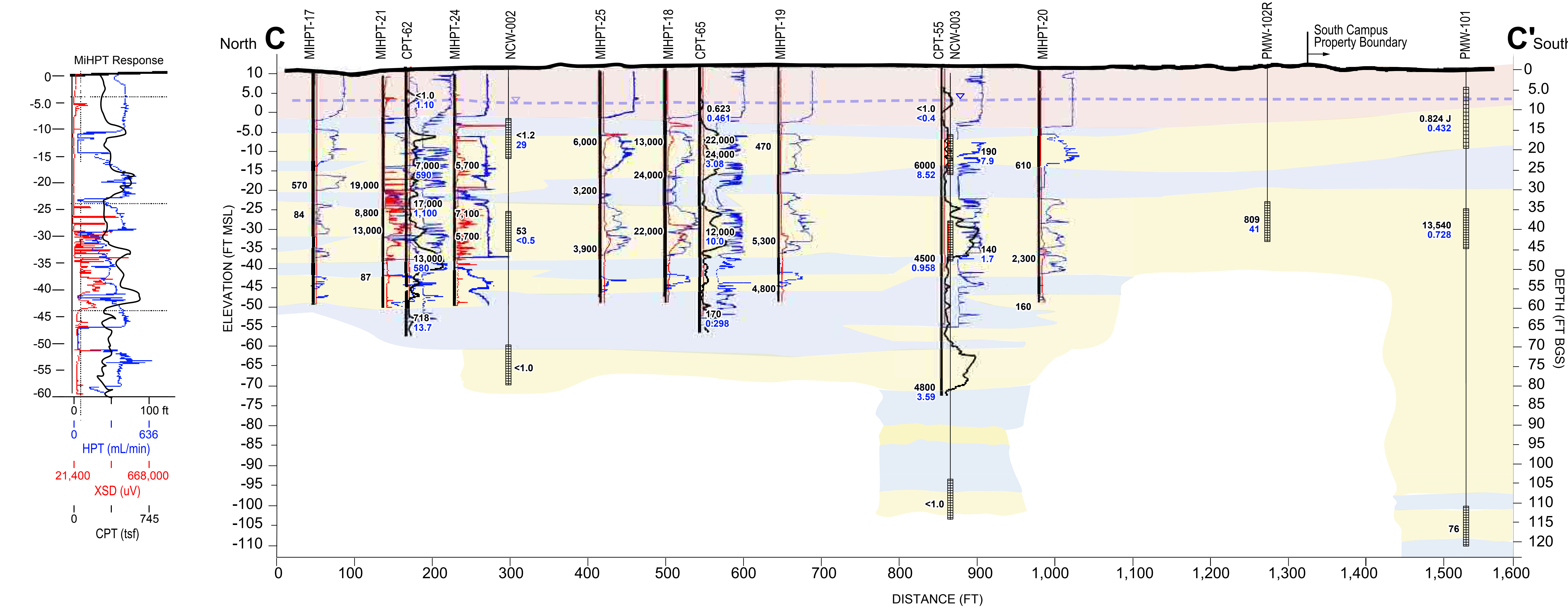
FT= Feet
BGS = Below ground surface
MSL= Mean Sea Level
XSD = Halogen Specific Detector Response
CPT= Cone Resistance, qt
HPT Flow = Hydraulic Pressure Flow
mL/min = micrograms per liter
uV = microvolts
tsf = ton per square feet
ug/L = micrograms per liter
19,000 ug/L = trichloroethene sample result
300 ug/L = 1,4-Dioxane sample result
Elevations surveyed in NAVD88

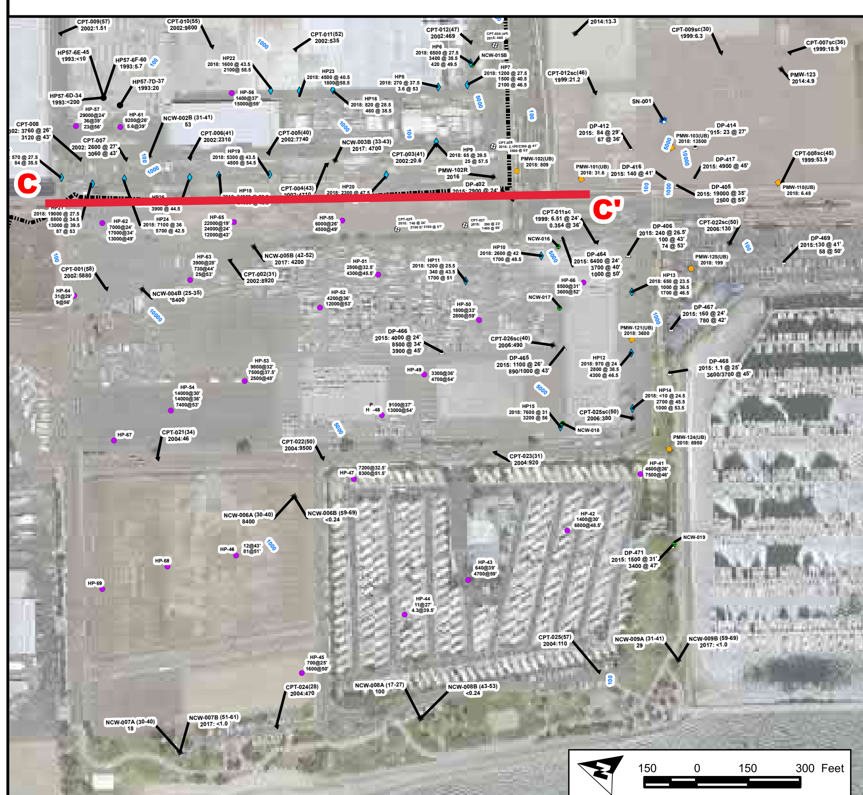
Geologic Cross-Section B-B'

AECOM

0 100' 200'
Vertical Exaggeration 5:1

CREATED BY: DB	DATE: 09/09/2019	FIG. NO:
PM: RS	PROJ. NO: 60545231	6





Legend

- HPT (mL/min)
- XSD (uV)
- CPT (tsf)
- Surcharge, new fill
- Fill/ Re-worked Native
- Coarser grained (sand, silty sand, clayey sand)
- Finer grained (clay and silt)
- Approximate Groundwater Elevation (July 2019)
- Screened Interval

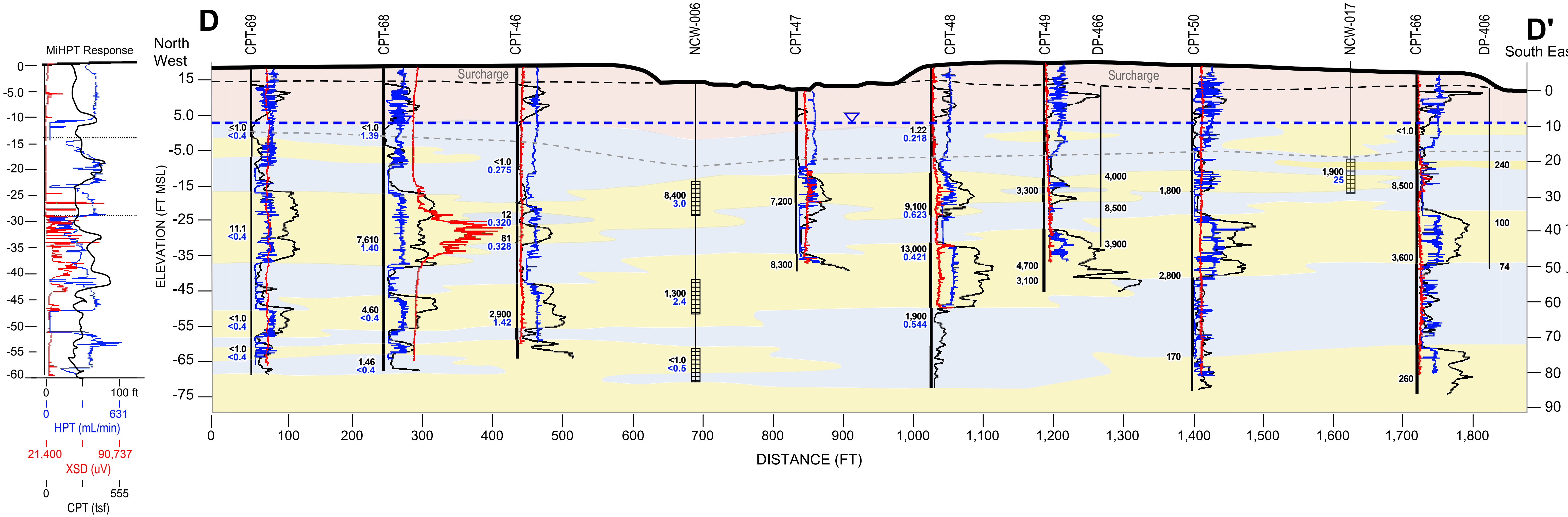
FT= Feet
BGS = Below ground surface
MSL= Mean Sea Level
XSD = Halogen Specific Detector Response
EC= Electrical Conductivity
CPT= Cone Resistance, qt
HPT Flow = Hydraulic Pressure Flow
mL/min = micrograms per liter
uV = microvolts
tsf = ton per square feet
mS/cm = milliSiemens per centimeter

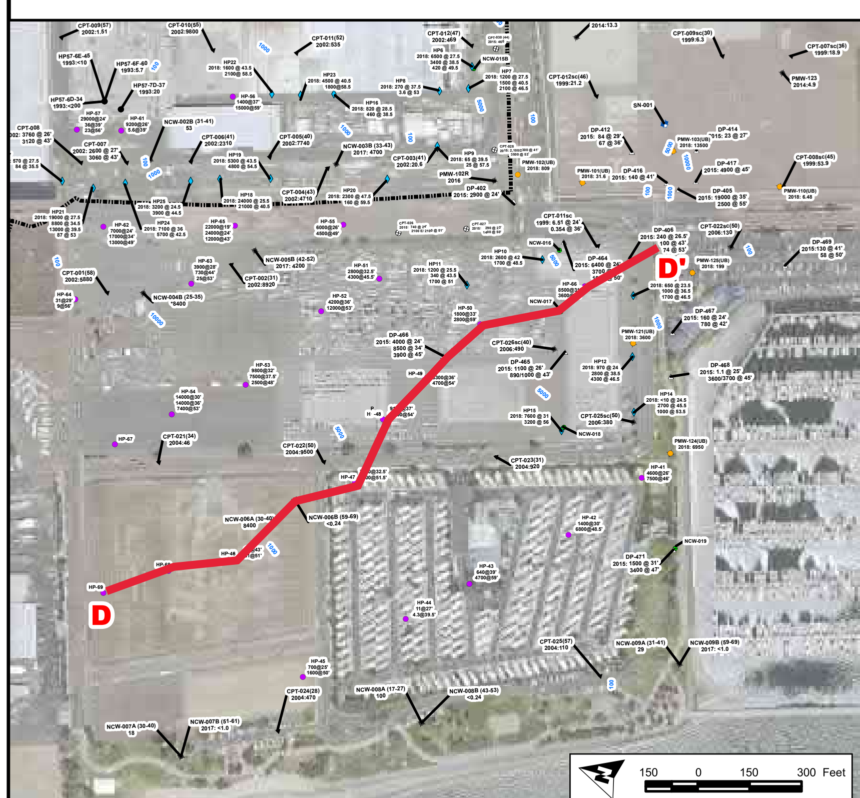
19,000 ug/L = trichloroethene sample result
300 ug/L = 1,4-Dioxane sample result

Elevations surveyed in NAVD88

Geologic Cross-Section C-C'

AECOM	0 100' 200' Vertical Exaggeration 5:1	CREATED BY: DB	DATE: 09/09/2019	FIG. NO:
		PM: RS	PROJ. NO: 60545231	7





Legend

- HPT (mL/min)
- XSD (uV)
- CPT (tsf)
- Surcharge, new fill
- Fill/ Re-worked Native
- Coarser grained (sand, silty sand, clayey sand)
- Finer grained (clay and silt)
- Inferred Base of Bay Deposits
- Approximate Groundwater Elevation (July 2019)
- Screened Interval

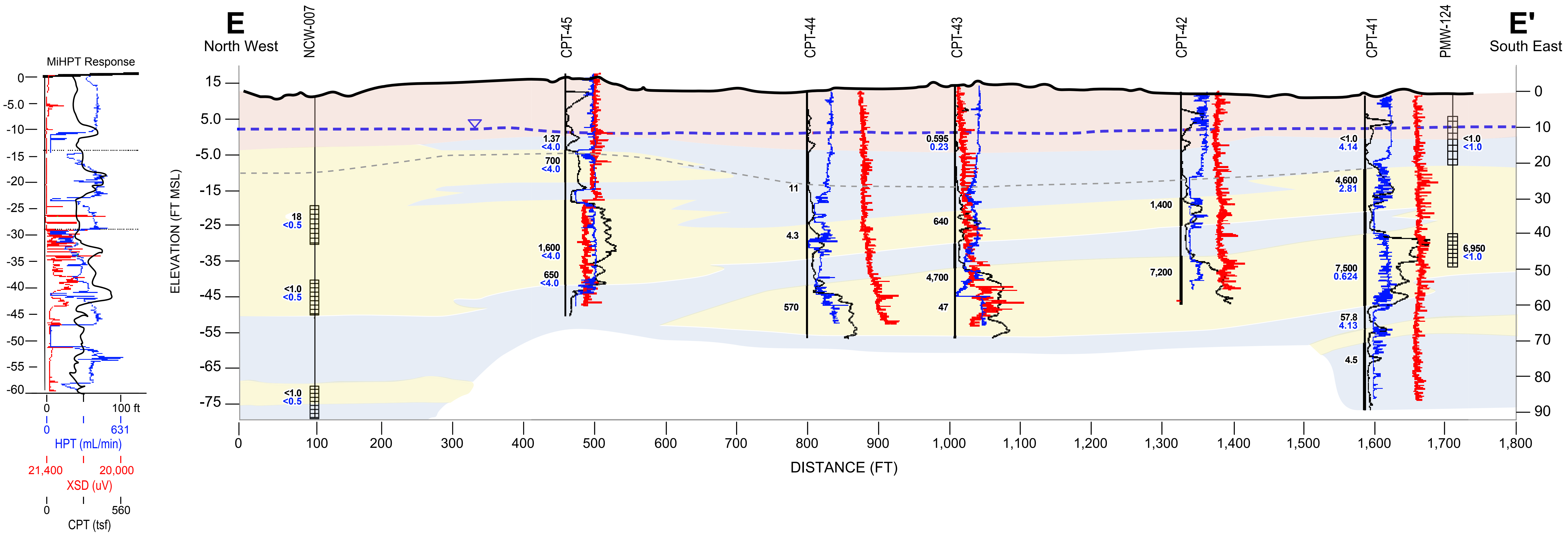
FT= Feet
BGS = Below ground surface
MSL= Mean Sea Level
XSD = Halogen Specific Detector Response
CPT= Cone Resistance, qt
HPT Flow = Hydraulic Pressure Flow
mL/min = micrograms per liter
uV = microvolts
tsf = ton per square feet
ug/L = micrograms per liter

19,000 ug/L = trichloroethene sample result
300 ug/L = 1,4-Dioxane sample result

Elevations surveyed in NAVD88

Geologic Cross-Section D-D'

AECOM	0 100' 200' Vertical Exaggeration 5:1	CREATED BY: DB	DATE: 09/09/2019	FIG. NO:
		PM: RS	PROJ. NO: 60545231	8



Legend

HPT (mL/min)

XSD (uV)

CPT (tsf)

Surcharge, new fill

Fill/ Re-worked Native

Coarser grained (sand, silty sand, clayey sand)

Finer grained (clay and silt)

Inferred Base of Bay Deposits

Approximate Groundwater Elevation (July 2019)

Screened Interval

FT= Feet

BGS = Below ground surface

MSL= Mean Sea Level

XSD = Halogen Specific Detector Response

EC= Electrical Conductivity

CPT= Cone Resistance, qt

HPT Flow = Hydraulic Pressure Flow

mL/min = micrograms per liter

uV = microvolts

tsf = ton per square feet

mS/cm = milliSiemens per centimeter

ug/L = micrograms per liter

19,000 ug/L = trichloroethene sample result

300 ug/L = 1,4-Dioxane sample result

Elevations surveyed in NAVD88

Geologic Cross-Section E-E'

AECOM

0 100' 200'

Vertical Exaggeration 5:1

CREATED BY: DB	DATE: 09/10/2019	FIG. NO:
PM: RS	PROJ. NO: 60545231	9

LEGEND

- Parcel H-3 Boundary
- Rohr Property Boundary
- South Campus Property Boundary
- TCE Concentration Contour (µg/L)*

2019 Additional Groundwater Investigation

- Hydropunch Boring — *Year: TCE Concentration @ Depth*

2018 Western Property Boundary/Oiler Shed/North of Marina Investigations

- Groundwater Monitoring Well — *(Screen Depth): Year: TCE Concentration*
- Hydropunch Boring Locations — *Year: TCE Concentration @ Depth*

2015 AECOM Investigation

- CPT-MIP Boring Locations — *(Depth) Year: TCE Concentration*

2015 Tetra Tech Investigation

- Tetra Tech Boring — *Year: TCE Concentration @ Depth*

2015 Haley & Aldrich Hydropunch Boring Locations

- Hydropunch Boring — *Year: TCE Concentration @ Depth*

Former Investigation Data Points

- UT — *(Depth) Year: TCE Concentration*
- CPT — *(Depth) Year: TCE Concentration*
- Boring; Well — *(Screen Depth): Year: TCE Concentration*
- Hydropunch — *(Depth) Year: TCE Concentration*

*NOTES:

Trichloroethene in micrograms per liter (µg/L); Depth in feet below ground surface.
Concentrations shown as ND or < are not detect for TCE
Newer data and data from wells were weighted more for contouring
Not all data shown were used for contouring
*For boring H3-DP14 - Data appears anomalous and will be confirmed through additional sampling.

SOURCES:
Monitoring Wells, CPT, Hydropunch, CPT/MIP Boring Locations (URS/AECOM 1999-2019);
South Campus Borings, Hydropunch Borings (Haley & Aldrich 2015);
Boring Locations (Tetra Tech 2015);
Aerial Imagery (SANDAG 2017).

COMPOSITE TCE ISOCONCENTRATION CONTOURS IN GROUNDWATER - ZONE A ROHR - CHULA VISTA

AECOM

150 0 150 300 Feet
SCALE: 1" = 150' (1:1,800)
SCALE CORRECT WHEN PRINTED AT 22X34

CREATED BY: DA	DATE: 9/30/2019	FIG. NO:
PM: RS	PROJ. NO: 60611775.01	10

LEGEND

- Parcel H-3 Boundary
- North Campus Property Boundary
- South Campus Property Boundary
- TCE Concentration Contour (µg/L)*

2019 Additional Groundwater Investigation

- Hydropunch Boring — *Year: TCE Concentration @ Depth*

2018 Western Property Boundary/Oiler Shed/North of Marina Investigations

- Groundwater Monitoring Well — *(Screen Depth): Year: TCE Concentration*
- Hydropunch Boring Locations — *Year: TCE Concentration @ Depth*

2015 AECOM Investigation

- CPT-MIP Boring Locations — *(Depth) Year: TCE Concentration*

2015 Haley & Aldrich Hydropunch Boring Locations

- Hydropunch Boring — *Year: TCE Concentration @ Depth*

Former Investigation Data Points

- CPT — *(Depth) Year: TCE Concentration*
- Boring; Well — *(Screen Depth): Year: TCE Concentration*
- Hydropunch — *(Depth) Year: TCE Concentration*

*NOTES:

Trichloroethene in micrograms per liter (µg/L); Depth in feet below ground surface.

Concentrations shown as ND or < are not detect for TCE

Newer data and data from wells were weighted more for contouring

Not all data shown were used for contouring

SOURCES:
Monitoring Wells, CPT, Hydropunch, CPT/MIP Boring Locations (URS/AECOM 1999-2019);
South Campus Borings, Hydropunch Borings (Haley & Aldrich 2015);
Aerial Imagery (SANDAG 2017).

COMPOSITE TCE ISOCONCENTRATION CONTOURS IN GROUNDWATER - ZONE UB ROHR - CHULA VISTA

AECOM

150 0 150 300 Feet

SCALE: 1" = 150' (1:1,800)

SCALE CORRECT WHEN PRINTED AT 22X34

CREATED BY: DA | DATE: 9/10/2019 | PM: RS | PROJ. NO: 60611775.01 | FIG. NO: 11

LEGEND

- Parcel H-3 Boundary
- North Campus Property Boundary
- South Campus Property Boundary
- TCE Concentration Contour (µg/L)*

ProposedCPTMIP - UB

2019 Additional Groundwater Investigation

- Hydropunch Boring — *Year: TCE Concentration @ Depth*

2018 Western Property Boundary/Oiler Shed/North of Marina Investigations

- Hydropunch Boring Locations — *Year: TCE Concentration @ Depth*

2015 AECOM Investigation

- CPT-MIP Boring Locations — *(Depth) Year: TCE Concentration*

Former Investigation Data Points

- CPT — *(Depth) Year: TCE Concentration*
- Boring; Well — *(Screen Depth): Year: TCE Concentration*

*NOTES:

Trichloroethene in micrograms per liter (µg/L); Depth in feet below ground surface.

Concentrations shown as ND or < are not detect for TCE

Newer data and data from wells were weighted more for contouring

Not all data shown were used for contouring

SOURCES:
Monitoring Wells, CPT, Hydropunch, CPT/MIP Boring Locations (URS/AECOM 1999-2019); South Campus Borings, Hydropunch Borings (Haley & Aldrich 2015); Aerial Imagery (SANDAG 2017).

COMPOSITE TCE ISOCONCENTRATION CONTOURS IN GROUNDWATER - ZONE LB ROHR - CHULA VISTA

AECOM

150 0 150 300 Feet

SCALE: 1" = 150' (1:1,800)

SCALE CORRECT WHEN PRINTED AT 22X34

CREATED BY: DA	DATE: 9/10/2019	FIG. NO:
PM: RS	PROJ. NO: 60611775.01	12

LEGEND

- Parcel H-3 Boundary
- North Campus Property Boundary
- South Campus Property Boundary
- 1,4 Dioxane Concentration Contour (µg/L)*

2019 Additional Groundwater Investigation

- Hydropunch Boring *Year: 1,4 Dioxane Concentration @ Depth*

2018 Western Property Boundary/Oiler Shed/North of Marina Investigations

- Groundwater Monitoring Well *Year: 1,4 Dioxane Concentration*
- Hydropunch Boring Locations *Year: 1,4 Dioxane Concentration*

Former Investigation Data Points

- Boring; Well *Year: 1,4 Dioxane Concentration*

NOTES:

1,4 Dioxane in micrograms per liter (µg/L); Depth in feet below ground surface.

Concentrations shown as ND or < are not detect for 1,4 Dioxane

Newer data and data from wells were weighted more for contouring

Not all data shown were used for contouring

*Samples collected in area re-graded in 2018 . Elevation is 4 - 15 ft above original ground surface .

SOURCES:
Monitoring Wells, CPT, Hydropunch, CPT/MIP Boring Locations (URS/AECOM 1999-2019); South Campus Borings, Hydropunch Borings (Haley & Aldrich 2015); Aerial Imagery (SANDAG 2017).

1,4-DIOXANE ISOCONCENTRATION CONTOURS
ZONE A
ROHR - CHULA VISTA

AECOM

150 0 150 300 Feet

SCALE: 1" = 150' (1:1,800)
SCALE CORRECT WHEN PRINTED AT 22X34

CREATED BY: DA	DATE: 3/5/2020	FIG. NO: 13
PM: RS	PROJ. NO: 60611775.01	

LEGEND

- Parcel H-3 Boundary
- North Campus Property Boundary
- South Campus Property Boundary
- 1,4 Dioxane Concentration Contour (µg/L)*

2019 Additional Groundwater Investigation

- Hydropunch Boring *Year: 1,4 Dioxane Concentration @ Depth*

2018 Western Property Boundary/Oiler Shed/North of Marina Investigations

- Groundwater Monitoring Well *Year: 1,4 Dioxane Concentration*
- Hydropunch Boring Locations *Year: 1,4 Dioxane Concentration*

Former Investigation Data Points

- Boring; Well *Year: 1,4 Dioxane Concentration*

*NOTES:

1,4 Dioxane in micrograms per liter (µg/L); Depth in feet below ground surface.

Concentrations shown as ND or < are not detect for 1,4 Dioxane

Newer data and data from wells were weighted more for contouring

Not all data shown were used for contouring

SOURCES:
Monitoring Wells, CPT, Hydropunch, CPT/MIP Boring Locations (URS/AECOM 1999-2019);
South Campus Borings, Hydropunch Borings (Haley & Aldrich 2015);
Aerial Imagery (SANDAG 2017).

1,4-DIOXANE ISOCONCENTRATION CONTOURS
ZONE UB
ROHR - CHULA VISTA

AECOM

150 0 150 300 Feet

SCALE: 1" = 150' (1:1,800)
SCALE CORRECT WHEN PRINTED AT 22X34

CREATED BY: DA	DATE: 3/5/2020	FIG. NO:
PM: RS	PROJ. NO: 60611775.01	14

LEGEND

Parcel H-3 Boundary

North Campus Property Boundary

South Campus Property Boundary

1,4 Dioxane Concentration Contour (µg/L)*

2019 Additional Groundwater Investigation

Hydropunch Boring *Year: 1,4 Dioxane Concentration @ Depth*

2018 Western Property Boundary/Oiler Shed/North of Marina Investigations

Hydropunch Boring Locations *Year: 1,4 Dioxane Concentration*

Former Investigation Data Points

Boring; Well *Year: 1,4 Dioxane Concentration*

*NOTES:

1,4 Dioxane in micrograms per liter (µg/L); Depth in feet below ground surface.

Concentrations shown as ND or < are not detect for 1,4 Dioxane

Newer data and data from wells were weighted more for contouring

Not all data shown were used for contouring

SOURCES:
Monitoring Wells, CPT, Hydropunch, CPT/MIP Boring Locations (URS/AECOM 1999-2019);
South Campus Borings, Hydropunch Borings (Haley & Aldrich 2015);
Aerial Imagery (SANDAG 2017).

1,4-DIOXANE ISOCONCENTRATION CONTOURS
ZONE LB
ROHR - CHULA VISTA

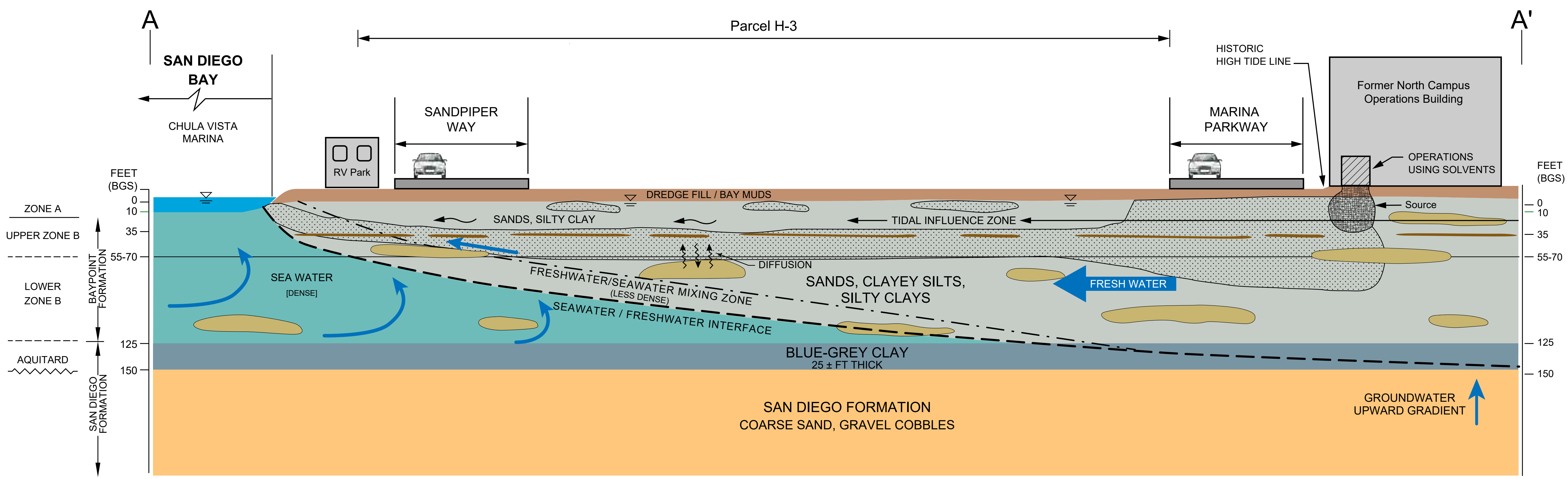
AECOM

150 0 150 300 Feet

SCALE: 1" = 150' (1:1,800)
SCALE CORRECT WHEN PRINTED AT 22X34

CREATED BY: DA | DATE: 3/2/2020 | FIG. NO: 15

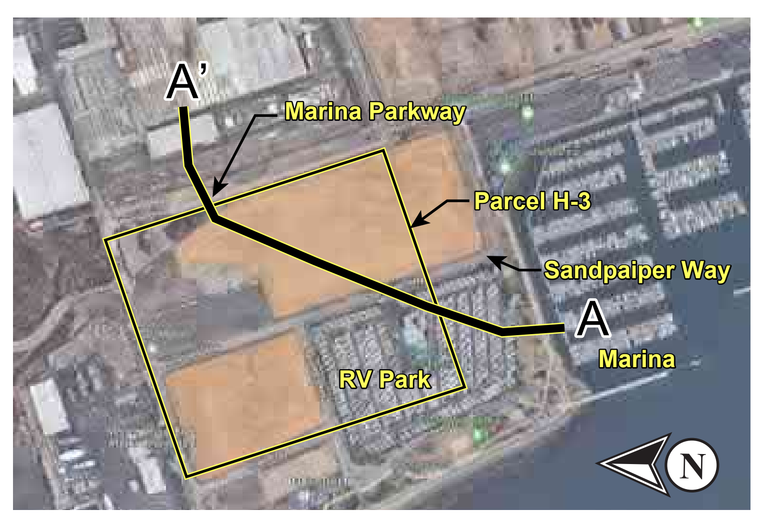
PM: RS | PROJ. NO: 60611775.01



SOURCE: Modified from Haley and Aldrich, 2019

LEGEND

- APPROXIMATE FRESHWATER / SEAWATER INTERFACE
- GROUNDWATER GRADIENT
- DIRECTION OF GENERAL GROUNDWATER FLOW AND DISSOLVED PHASE CHEMICAL MOVEMENT (VOC'S)
- BGS — BELOW GROUND SURFACE
- VOC's — VOLATILE ORGANIC COMPOUNDS
- APPROXIMATE GROUNDWATER ELEVATION
- VOC's IN GROUNDWATER
- DIFFUSION
- CLAY LENS
- CLAY LENSE
- VARIABLE



ROHR, INC., CHULA VISTA

Conceptual Site Model Summary Figure

AECOM

SCALE: NONE
September 2019

FIGURE 16

CONTRIBUTING SOURCE	PRIMARY IMPACTED MEDIUM	TRANSPORT MECHANISM	SECONDARY IMPACTED MEDIUM	EXPOSURE ROUTE	POTENTIAL HUMAN RECEPTORS AND EXPOSURE PATHWAYS			
					On-Site Redevelopment Construction Worker	**Post-Development On-Site Hotel Guest/Recreational Visitor (Adult/Child)**	**Post-Development On-Site Landscaper/Utility Worker (Adult)**	**Post-Development On-Site Commercial/Industrial Worker (Adult)**
Releases of Chemicals of Concern at Adjacent Rohr North Campus	Groundwater at Rohr North Campus	Groundwater Flow from North Campus to Parcel H-3	Saturated Subsurface Soil	Incidental Ingestion: Dermal Contact: Inhalation of Particulates:	Potentially Complete	Incomplete	Potentially Complete	Incomplete
			Groundwater in Domestic/ Agricultural Wells	Incidental Ingestion: Dermal Contact: Inhalation of Vapor:	Incomplete	Incomplete	Incomplete	Incomplete
			Groundwater Ponded In Trenches	Incidental Ingestion: Dermal Contact: Inhalation of Vapor:	Potentially Complete	Incomplete	Potentially Complete	Incomplete
		Volatilization of VOCs Through the Soil Column	Air	Inhalation of Ambient Vapor:	Potentially Complete	Insignificant	Potentially Complete	Insignificant
				Inhalation of Indoor Vapor:	Incomplete	Potentially Complete	Incomplete	Potentially Complete

Notes:
VOCs - volatile organic compounds
Surface and vadose zone soil is not a medium of concern for North Campus-related impacts at Parcel H-3
Groundwater is not a current or future drinking water source and will not be used in the proposed water park.
Incomplete - Receptor exposure is incomplete based on conditions and uses (i.e., access limitations and/or distance).
Insignificant - Receptor exposure is potentially complete but considered insignificant based on conditions and uses (i.e., distance).

Figure 17
Human Health Conceptual Site Model
H-3 Parcel
ROHR - Chula Vista

AECOM Imagine it. Delivered.

LEGEND

- Rohr Property Boundary
- Parcel H3 Boundary
- Convention Center Exposure Area
- Water Park Exposure Area

2019 Investigation Points

- CPT/MIP Boring
- Hydropunch Boring

2015 Haley & Aldrich Hydropunch Boring Locations

- Hydropunch Boring

Historic Wells & Borings

- CPT

2015 TetraTech Investigation Data Points

- Boring Location

2018 Terracon Vapor Data Points

- Vapor Data Points

SOURCES:
Wells, Borings, CPT Locations (URS/AECOM 1999-2018); Vapor Data Points (Terracon 2018); Boring Locations (TetraTech 2015); Shallow Boring Data (Haley & Aldrich 2016-2018); Aerial Imagery (SANDAG 2017).

HHRA EXPOSURE AREAS

AECOM

100 0 100 200 Feet

SCALE: 1" = 100' (1:1,200)

SCALE CORRECT WHEN PRINTED AT 22X34

CREATED BY: IIN	DATE: 12/19/2019	FIG. NO: 18
PM: RS	PROJ. NO: 60613587.02	

LEGEND

- Parcel H-3 Boundary
- North Campus Property Boundary
- South Campus Property Boundary
- TCE Concentration Contour (µg/L)*
- EVO Grid

2019 Additional Groundwater Investigation

- Hydropunch Boring *Year: TCE Concentration @ Depth*

2018 Western Property Boundary/Oiler Shed/North of Marina Investigations

- Groundwater Monitoring Well *(Screen Depth): Year: TCE Concentration*
- Hydropunch Boring Locations *Year: TCE Concentration @ Depth*

2015 AECOM Investigation

- CPT-MIP Boring Locations *(Depth) Year: TCE Concentration*

2015 Tetra Tech Investigation

- Tetra Tech Boring *Year: TCE Concentration @ Depth*

2015 Haley & Aldrich Hydropunch Boring Locations

- Hydropunch Boring *Year: TCE Concentration @ Depth*

Former Investigation Data Points

- CPT *(Depth) Year: TCE Concentration*
- Boring; Well *(Screen Depth): Year: TCE Concentration*
- Hydropunch *(Depth) Year: TCE Concentration*

*NOTES:

Trichloroethene in micrograms per liter (µg/L); Depth in feet below ground surface.

Concentrations shown as ND or < are not detect for TCE

Newer data and data from wells were weighted more for contouring

Not all data shown were used for contouring

EVO - emulsified vegetable oil

SOURCES:
Monitoring Wells, CPT, Hydropunch, CPT/MIP Boring Locations (URS/AECOM 1999-2019);
South Campus Borings, Hydropunch Borings (Haley & Aldrich 2015);
Aerial Imagery (SANDAG 2017).

Alternative 1 - EISB, MNA, and Engineered Controls
Rohr - Chula Vista

AECOM

150 0 150 300 Feet

SCALE: 1" = 150' (1:1,800)
SCALE CORRECT WHEN PRINTED AT 22X34

CREATED BY: DA	DATE: 3/16/2020	FIG. NO:
PM: RS	PROJ. NO: 60624313.2	19

LEGEND

- Existing Monitoring Wells
- New Permanent and Replacement Monitoring Wells
- Proposed Hydropunch Locations
- PRB Confirmation Soil Borings and Hydropunch Sample Locations
- Temporary Monitoring Wells

2019 Investigation Points

- Hydropunch Boring
- TCE Concentration Contour (μg/L)*
- WDR Monitoring Points (only UB wells)
- Barriers
- EVO Grid
- North Campus Property Boundary
- South Campus Property Boundary
- Parcel H-3 Boundary

*NOTES:

- EVO – emulsified vegetable oil
- ISCR/EISB – in situ chemical reduction/ enhanced in situ bioremediation
- TCE – trichloroethene

SOURCES:
Aerial Imagery (SANDAG 2017).

Alternative 2 – ISCR/EISB, MNA, and Engineered Controls
Rohr - Chula Vista

100 0 100 200 Feet

SCALE: 1" = 100' (1:1,200)
SCALE CORRECT WHEN PRINTED AT 22X34

AECOM

CREATED BY: DA	DATE: 3/11/2020	FIG. NO: 20
PM: RS	PROJ. NO: 60624313.2	

LEGEND

- TCE Concentration Contour (µg/L)*
- Cast In Place Piles
- Offset Injection Location
- ISCR Barrier

* µg/L: micrograms per liter

SOURCES:
Aerial Imagery (SANDAG 2017).

Cast-In-Place Piles and Offset Injection Locations
ROHR - CHULA VISTA

AECOM

30 0 30 60 Feet
SCALE: 1" = 30' (1:360)
SCALE CORRECT WHEN PRINTED AT 22X34

CREATED BY: DA | DATE: 3/11/2020
PM: RS | PROJ. NO: 60624313

FIG. NO:
21

LEGEND

- Parcel H-3 Boundary
- North Campus Property Boundary
- South Campus Property Boundary
- 1,4 Dioxane Concentration Contour (µg/L)*
- MNA Monitoring Wells

SOURCES:
Monitoring Wells, CPT, Hydropunch, CPT/MIP Boring Locations (URS/AECOM 1999-2019);
South Campus Borings, Hydropunch Borings (Haley & Aldrich 2015);
Aerial Imagery (SANDAG 2017).

MNA WELLS AND 1,4-DIOXANE ISOCONCENTRATION CONTOURS - ZONE UB
ROHR - CHULA VISTA

AECOM

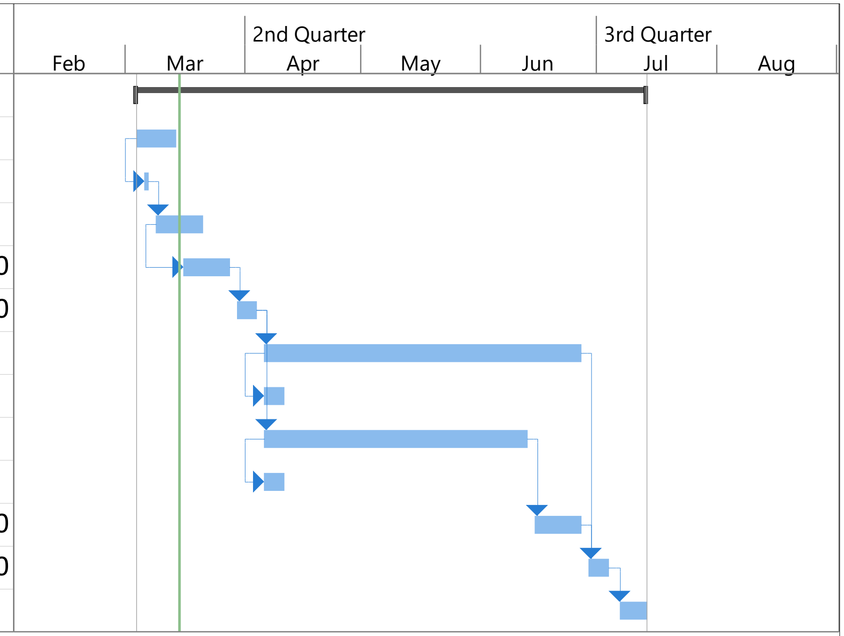
150 0 150 300 Feet

SCALE: 1" = 150' (1:1,800)
SCALE CORRECT WHEN PRINTED AT 22X34

CREATED BY: DA | DATE: 3/12/2020 | FIG. NO: 22

PM: RS | PROJ. NO: 60611775.01

ID		Task Mode	Task Name	Duration	Start
1			**Parcel H-3 Schedule**	**93 days**	**Wed 3/4/20**
2			Permitting/Site Access	8 days	Wed 3/4/20
3			Mobilization	1 day	Fri 3/6/20
4			Location and Utility Survey	10 days	Mon 3/9/20
5			Install Groundwater Monitoring Wells	10 days	Mon 3/16/20
6			Baseline Groundwater Sampling Event	5 days	Mon 3/30/20
7			EVO Grid Injections	60 days	Mon 4/6/20
8			ROI Confirmation Assessment	5 days	Mon 4/6/20
9			EDS-ER/ZVI Barrier Injections	50 days	Mon 4/6/20
10			ROI Confirmation Assessment	5 days	Mon 4/6/20
11			EDS-ER/ZVI Barrier 1 Injections	10 days	Mon 6/15/20
12			Post-Injection Initial Sampling Event	5 days	Mon 6/29/20
13			Demobilization	5 days	Tue 7/7/20



Project: Parcel H-3 Field Implementation Schedule
Date: Sun 3/15/20

ROHR, INC., CHULA VISTA IMPLEMENTATION SCHEDULE

AECOM FIGURE 23

Task	Inactive Summary	External Tasks
Split	Manual Task	External Milestone
Milestone	Duration-only	Deadline
Summary	Manual Summary Rollup	Progress
Project Summary	Manual Summary	Manual Progress
Inactive Task	Start-only	
Inactive Milestone	Finish-only	

Tables

Table 1
Well Construction Details

Well No.	Stratigraphic Zone	Date Installed	Well Diameter / Construction	TOC Elevation (feet MSL)	Total Well Depth (feet btoc)	Approx. Screen Interval Depth (feet btoc)	Screen Interval Elevation (feet MSL)
North Campus Wells:							
NCW-001A	A	05/23/06	4" PVC	9.73	15.40	5 - 15	4.73 to -5.27
NCW-001B	UB	05/19/06	4" PVC	9.76	50.41	40 - 50	-30.24 to -40.24
NCW-001C	LB	05/18/06	4" PVC	9.37	100.62	90 -100	-80.63 to -90.63
NCW-002A	A	05/31/06	4" PVC	7.93	16.85	7 - 17	0.93 to -9.07
NCW-002B	UB	05/31/06	4" PVC	7.82	40.50	30.5 - 40.5	-22.68 to -32.68
NCW-002C	LB	06/23/06	4" PVC	7.99	74.65	65 - 75	-57.01 to -67.01
NCW-003A	A	05/25/06	4" PVC	8.75	21.07	11 - 21	-2.25 to -12.25
NCW-003B	UB	05/25/06	4" PVC	8.79	43.00	33 - 43	-24.21 to -34.21
NCW-003C	LB	05/24/06	4" PVC	8.55	110.25	100 - 110	-91.45 to -101.45
NCW-004A	A	05/09/06	4" PVC	11.26	15.40	5 - 15	6.26 to -3.74
NCW-004B	UB	05/12/06	4" PVC	11.44	35.20	25 - 35	-13.56 to -23.56
NCW-004C	LB	05/09/06	4" PVC	11.41	111.15	101 - 111	-89.59 to -99.59
NCW-005A	A	05/16/06	4" PVC	12.32	15.40	5 - 15	7.32 to -2.68
NCW-005B	UB	05/17/06	4" PVC	12.28	52.30	42 - 52	-29.72 to -39.72
NCW-005C	LB	05/16/06	4" PVC	12.27	94.60	85 - 95	-72.73 to -82.73
NCW-006A	UB	09/20/12	4" PVC	13.75	40.20	30 - 40	-16.25 to -26.25
NCW-006B	UB	09/20/12	4" PVC	13.61	69.20	59 - 69	-45.39 to -55.39
NCW-006C	LB	09/19/12	4" PVC	13.33	90.66	80 - 90	-66.67 to -76.67
NCW-007A	UB	10/09/12	4" PVC	9.83	40.43	30 - 40	-20.17 to -30.17
NCW-007B	UB	10/09/12	4" PVC	9.87	61.25	51 - 61	-41.13 to -51.13
NCW-007C	LB	10/08/12	4" PVC	9.56	91.01	81 - 91	-71.44 to -81.44
NCW-008A	UB	10/03/12	4" PVC	11.25	26.27	16 - 26	-4.75 to -14.75
NCW-008B	UB	10/03/12	4" PVC	11.04	53.66	43 - 53	-31.96 to -41.96
NCW-008C	LB	10/02/12	4" PVC	11.37	97.87	87.5 - 97.5	-76.13 to -86.13
NCW-009A	UB	09/28/12	4" PVC	11.04	40.98	31 - 41	-19.96 to -29.96
NCW-009B	UB	09/27/12	4" PVC	10.72	68.37	58 - 68	-47.28 to -57.28
NCW-009C	LB	09/26/12	4" PVC	10.82	93.07	83 - 93	-72.18 to -82.18
NCW-016	UB	09/27/18	2" PVC	13.86	31.14	21 - 31	-7.14 to -17.14
NCW-017	UB	09/26/18	2" PVC	20.70	38.72	28.5 - 38.5	-7.80 to -17.80
NCW-018	UB	09/25/18	2" PVC	15.06	35.33	25 - 35	-9.94 to -19.94
NCW-019	UB	10/01/18	2" PVC	11.13	52.28	42 - 52	-30.87 to -40.87
NCW-020	A	10/05/18	2" PVC	8.78	21.53	11.5 - 21.5	-2.72 to -12.72
South Campus Wells:							
PMW-121(A)	A	2002	4" PVC	11.97	19.50	4.5 - 19.5	-7.47 to -7.53
PMW-121(UB)	UB	2002	4" PVC	11.93	50.00	35 - 45	-23.07 to -33.07
PMW-124(A)	A	2009	4" PVC	10.93	20.00	5 - 20	5.93 to -9.07
PMW-124(UB)	UB	2009	4" PVC	11.06	50.00	35 - 45	-23.94 to -33.94

Notes:
bgs: below ground surface
btoc: Below top of casing
MSL: Mean sea level datum, NAD83, NAVD88
UB : Upper Zone B
LB : Lower Zone B

Table 2
Summary of COPC Detections in Groundwater
Parcel H-3

Analytes	Unit	MCL	Number of Samples	Number of Detects	Number of MCL Exceedances	Maximum Detected Concentration	Sample ID for Maximum Concentration	Minimum Detected Concentration	Sample ID for Minimum Concentration
Extractable Fuel Hydrocarbons									
PHC AS DIESEL FUEL	mg/L		7	3	0	1.9	GWS01166 (NCW-004B)	1.3	GWS01169 (NCW-005B)
Volatile Organic Compounds									
Trichloroethene (TCE)	mg/L	0.005	199	137	121	24	HP65-24/GWS01601	0.000595	HP43-8/GWS01759
cis-1,2-Dichloroethene	mg/L	0.006	199	125	99	5.3	HP62-34/GWS01629	0.000325	HP65-8/GWS01754
Vinyl chloride	mg/L	0.0005	199	80	67	0.72	HP62-34/GWS01629	0.00025	HP44-27/GWS01644
1,1-Dichloroethene	mg/L	0.006	196	80	51	1.5	HP66-31/GWS01671	0.00023	HP50-81/GWS01679
Tetrachloroethylene	mg/L	0.005	168	52	24	0.37	GWS00005 CPT-002-031	0.00036	HP64-56/GWS01615
1,1-Dichloroethane	mg/L	0.005	165	21	17	0.11	HP66-31/GWS01671	0.000262	HP48-72/GWS01737
Carbon tetrachloride	mg/L	0.0005	165	21	14	0.018	CPT-027W-56	0.00033	HP66-84/GWS01673
1,2-Dichloroethane	mg/L	0.0005	165	20	10	0.0086	HP63-28/GWS01603	0.00023	HP66-84/GWS01673
trans-1,2-Dichloroethylene	mg/L	0.01	196	28	6	0.05	HP62-24/GWS01628	0.00052	NCW-019/GWS01711
Benzene	mg/L	0.001	165	6	2	0.0046	HP45-50/GWS01622	0.00031	HP41-72.5/GWS01653
Chloroform	mg/L	0.08	165	33	0	0.021	HP55-26/GWS01611	0.00031	HP50-81/GWS01679
Carbon disulfide	mg/L		168	15	0	0.0036	H3-DP1-GW-12.0	0.00085	HP44-39.5/GWS01645
Dibromodifluoromethane	mg/L		12	12	0	0.0602	GWS00006 CPT-002-048	0.0498	GWS00001 CPT-001-032
1,1,2-Trichloroethane	mg/L	0.005	165	4	0	0.003	HP66-52/GWS01672	0.00171	DUP-2/GWS01747
Acetone	mg/L		165	4	0	0.0375	HP41-64/GWS01742	0.01	HP44-39.5/GWS01645
1,1,1-Trichloroethane	mg/L	0.2	165	2	0	0.0612	GWS00031 CPT-011-010	0.00107	HP41-8.5/GWS01739
m,p-Xylene	mg/L		137	2	0	0.0784	GWS00002 CPT-001-058	0.0762	GWS00001 CPT-001-032
2-Butanone (MEK)	mg/L		165	1	0	0.00395	HP41-64/GWS01742	0.00395	HP41-64/GWS01742
Bromodichloromethane	mg/L	0.1	165	1	0	0.000533	HP67-81/GWS01734	0.000533	HP67-81/GWS01734
Bromoform	mg/L	0.08	165	1	0	0.000698	HP67-81/GWS01734	0.000698	HP67-81/GWS01734
Chloromethane	mg/L		196	1	0	0.00063	H3-DP4-GW-8.0	0.00063	H3-DP4-GW-8.0
Dibromochloromethane	mg/L	0.1	165	1	0	0.000772	HP67-81/GWS01734	0.000772	HP67-81/GWS01734
Ethylbenzene	mg/L	0.3	155	1	0	0.0016	HP45-50/GWS01622	0.0016	HP45-50/GWS01622
Styrene	mg/L	0.1	165	1	0	0.003	HP63-28/GWS01603	0.003	HP63-28/GWS01603
Toluene	mg/L	0.15	196	1	0	0.00021	HP41-72.5/GWS01653	0.00021	HP41-72.5/GWS01653
1,4-Dioxane									
1,4-Dioxane	mg/L	0.001 (1)	87	60	42	1.1	HP62-34/GWS01629	0.000218	HP48-15.5/GWS01738
Total Metals									
Manganese	mg/L	0.05	25	24	23	6.31	GWS01173 (NCW-006C)	0.0183	NCW-006A/GWS01606
Iron	mg/L	0.3	18	14	12	5.35	NCW-008B/GWS01685	0.185	GWS01284 NCW-009A
Chromium	mg/L	0.05	1	1	1	0.208	GWS00246	0.208	GWS00246
Calcium	mg/L		21	21	0	545	GSW01285(NCW-009B)	15.3	GWS00008 CPT-002-009
Chromium (Hexavalent)	mg/L		17	1	0	0.031	GWS00246	0.031	GWS00246
Magnesium	mg/L		21	21	0	1590	GSW01285(NCW-009B)	21.1	GWS00008 CPT-002-009
Potassium	mg/L		19	19	0	386	GSW01285(NCW-009B)	53.4	GWS00008 CPT-002-009
Sodium	mg/L		21	21	0	12900	GSW01285(NCW-009B)	782	GWS01272 NCW-005A
Dissolved Metals									
Manganese	mg/L	0.05	18	18	17	1.07	GWS00004 CPT-001-011	0.0257	NCW-004A/GWSO1680
Arsenic	mg/L	0.01	28	16	11	0.216	GWS00123	0.00514	GWS00008 CPT-002-009
Lead	mg/L	0.015	28	14	9	0.729	GWS00123	0.00898	NCW-006C/GWS01686
Iron	mg/L	0.3	18	15	7	1.15	NCW-006C/GWS01686	0.0749	GWS00008 CPT-002-009
Beryllium	mg/L	0.004	28	6	3	0.0104	NCW-004C/GWSO1681	0.0027	NCW-0068/GWS01705
Antimony	mg/L	0.006	28	2	2	0.057	NCW-004C/GWSO1681	0.0425	NCW-005C/GWSO1683
Cadmium	mg/L	0.005	28	5	2	0.0299	GWS00123	0.00212	NCW-008B/GWS01685
Chromium	mg/L	0.05	28	2	1	0.459	GWS00123	0.00875	NCW-004C/GWSO1681

Table 2
Summary of COPC Detections in Groundwater
Parcel H-3

Analytes	Unit	MCL	Number of Samples	Number of Detects	Number of MCL Exceedances	Maximum Detected Concentration	Sample ID for Maximum Concentration	Minimum Detected Concentration	Sample ID for Minimum Concentration
Nickel	mg/L	0.1	28	7	1	0.325	GWS00123	0.0141	NCW-005B/GWS01709
Selenium	mg/L	0.05	28	4	1	0.115	NCW-005C/GWSO1683	0.0132	GWS00001 CPT-001-032
Barium	mg/L	1	28	19	0	0.869	GWS00123	0.0186	NCW-005A/GWSO1682
Cobalt	mg/L		28	2	0	0.103	GWS00123	0.00563	NCW-006A/GWS01710
Copper	mg/L	1	28	2	0	0.603	GWS00123	0.0081	DUP-1/GWS01718
Mercury	mg/L	0.002	28	6	0	0.000859	NCW-019/GWS01711	0.000116	GWS00007 CPT-002-099
Molybdenum	mg/L		28	19	0	0.132	GWS00031 CPT-011-010	0.00992	NCW-007A/GWS01687
Silver	mg/L	0.1	28	3	0	0.00417	GWS00002 CPT-001-058	0.00138	GWS00004 CPT-001-011
Thallium	mg/L	0.002	28	0	0	-	-	-	-
Vanadium	mg/L		28	8	0	0.407	GWS00123	0.0119	NCW-004C/GWSO1681
Zinc	mg/L	5	28	1	0	1.6	GWS00123	1.6	GWS00123
General Water Quality Parameters									
Chloride	mg/L	500	64	64	61	28000	GSW01285(NCW-009B)	110	NCW-005A/GWSO1682
Sulfate	mg/L	500	64	64	38	3820	HP41-64/GWS01742	89	NCW-005A/GWSO1682
Dissolved Organic Carbon (DOC)	mg/L		35	35	0	14.8	NCW-004A/GWSO1680	0.316	NCW-006C/GWS01686
Nitrate	mg/L	45	53	30	0	43	HP51-45.5/GWS01650	0.11	GWS01272 NCW-005A
Methane	mg/L		25	21	0	9	NCW-004A/GWSO1680	0.000186	NCW-006A/GWS01606
Hardness (as CaCO3)	mg/L CaCO3		19	19	0	7500	GSW01285(NCW-009B)	44	NCW-005A/GWSO1682
Alkalinity	mg/L CaCO3		15	15	0	1540	GWS00008 CPT-002-009	152	GWS00003 CPT-001-100
Ferrous Iron	mg/L		19	12	0	2.92	NCW-008B/GWS01685	0.0638	NCW-005A/GWSO1682
pH	pH units		12	12	0	8.07	GWS00008 CPT-002-009	6.86	GSW01285(NCW-009B)
Phosphorous, Total Orthophosphate (as P)	mg/L		19	5	0	2.2	NCW-019/GWS01711	0.36	GWS01272 NCW-005A
Surfactants	mg/L		3	3	0	0.39	GWS00150(34)	0.2	GWS00151(50)
Fluoride	mg/L	2	2	2	0	0.85	CPT-026W-51	0.72	CPT-027W-56
MBAS	mg/L	0.5	8	1	1	0.963	GWS00008 CPT-002-009	0.963	GWS00008 CPT-002-009
Nitrogen, Nitrite	mg/L	1	2	0	0	-	-	-	-

Notes:
mg/L: milligrams per liter
MCL: Maximum Contamination Level
(1): California Division of Drinking Water Notification Level

TABLE 3
TECHNOLOGY SCREENING
INTERIM REMEDIATION FOR PARCEL H-3
CHULA VISTA, CALIFORNIA

Technology Class	Process Option	Technical Approach	Target	Implementation Comments	Screening Outcome
Enhanced Insitu Bioremediation	Anaerobic	Use the natural metabolic process of microorganisms, combined with bioaugmentation and the addition of a substrate, to facilitate degradation of COPCs	Diffuse Plume	Evidence of naturally occurring biodegradation of TCE has already been demonstrated in the groundwater beneath Parcel H-3 through the detection of typical TCE reductive dechlorination byproducts such as cis-1,2-dichloroethene (cis-1,2-DCE) and vinyl chloride (VC). Enhancement of this natural process was demonstrated in a recent enhanced in-situ bioremediation pilot-test on the South Campus that was successful in significantly reducing TCE to ethene and ethane and creating anaerobic and reducing conditions in groundwater that would support additional biodegradation of chlorinated VOCs with greater attenuation rates than natural conditions. While the presence of high concentrations of sulfate (a competing electron acceptor) in Parcel H-3 groundwater may interfere with complete biodegradation and/or increase the quantity of carbon substrate needed for effective enhanced biodegradation implementation, this will be partially offset by the reduction of naturally occurring sulfate which would lead to the formation of sulfides, which in turn would facilitate abiotic reduction of VOCs. Full-scale implementation for a site with a TCE distribution similar to Parcel H-3 would consider the use of direct push injections using emulsified vegetable oil (EVO) in a grid pattern.	Retained
Combined Insitu Chemical Reduction (ISCR) and Enhanced Insitu Bioremediation (ESIB)	Anaerobic	Injection of an amendment that combines zero valent iron (ZVI) with a carbon source in a grid or barrier approach.	Diffuse Plume	Similar to the Enhanced Insitu Bioremediation option discussed above, the injection of a dual-component amendment combines the benefits of enhanced biodegradation with the abiotic degradation pathway facilitated by the presence of zero valent iron (ZVI). The abiotic pathway does not generate dechlorination byproducts and ZVI typically lasts 5 or more years in the subsurface. Results of bench scale testing performed at the Oiler Shed area showed effective contaminant degradation of contaminants of concern. While the presence of high concentrations of sulfate (a competing electron acceptor) in Parcel H-3 groundwater may interfere with complete biodegradation and/or increase the quantity of carbon substrate needed for effective enhanced biodegradation implementation, this will be partially offset by the reduction of naturally occurring sulfate which would lead to the formation of sulfides, which in turn would facilitate abiotic reduction of VOCs. In addition, EVO may be added in combination with the dual-component amendment to serve as a sacrificial donor to address the elevated sulfate concentrations. Full-scale implementation for a site with a TCE distribution similar to Parcel H-3 would consider the use of direct push injections of ISCR/ESIB amendments to form a downgradient barrier perpendicular to groundwater flow. Barrier cost effectiveness will depend on the use of longer lasting substrates (i.e. 5 years) that would allow for wider spacing on the barriers after accounting for water/plume migration velocities of approximately 150 feet per year. These longer lasting substrates would include EHC (80% carbon/20% zero valent iron [ZVI]) and ELS (fast-acting soluble carbon solution to address elevated sulfate).	Retained
Migration Control	Pump and Treat	Install series of groundwater extraction wells, piping network, and an above ground treatment system	Diffuse Plume	Pump and treat or similar technologies are typically used to prevent further downgradient migration of chemicals of concern. These technologies are very inefficient as high volumes of low concentration waters are typically extracted for decades resulting in very low mass removal rates over time. For Parcel H-3, implementation of this technology would be further reduced by the slow back-diffusion of TCE and other VOCs from the fine-grained soil layers that have already adsorbed mass from the migration of the existing TCE/VOC plumes. Case studies of similar sites have shown that pump and treat systems have not been able to meet cleanup goals in reasonable timeframes, with some sites showing repeated rebounds to similar concentrations (i.e., no significant effect from pump and treat). In addition, the low permeability of the soil beneath Parcel H-3 may not permit significant flow, which would require multiple wells and the associated infrastructure for plume containment. Tidal influence could result in the lack of migration control, including changes in lateral and vertical migration patterns due to the presence of a higher density seawater wedge, and by causing complications in the aboveground water treatment system due to shifts in groundwater salinity and increased precipitation potential. Treated water may need to be reinjected which will be geochemically difficult due to the elevated concentrations of total dissolved solids and general minerals in the extracted water.	Eliminated

TABLE 3
TECHNOLOGY SCREENING
INTERIM REMEDATION FOR PARCEL H-3
CHULA VISTA, CALIFORNIA

Technology Class	Process Option	Technical Approach	Target	Implementation Comments	Screening Outcome
Chemical Oxidation	ISCO Injections	Injection of a chemical oxidant in a grid	Source Areas	Measured soil oxidant demand (SOD) is low at 1.5 grams of oxidant to kilograms of soil, which is beneficial in reducing the oxidant mass needed for achieving remedial objectives and the associated costs. However, ISCO injections have poor effectiveness at sites like Parcel H-3 that have high percentages of low permeability clays and silts, resulting in channeling into coarser-grained zones and/or limited injection radius, which leads to the need for more injection points to provide coverage of the target area. Also, VOCs back-diffusing from clays and silts will require multiple injections to address recurring spikes of VOC concentrations. Therefore, ISCO injections are not cost effective for diffuse plume remediation especially in areas with adsorbed TCE/other VOCs. Also, ISCO can result in an increase in hexavalent chromium concentrations due to the temporary shift to highly oxidative conditions from oxidant use, with the caveat that these concentrations typically revert/dissipate as groundwater geochemistry returns to native conditions. In addition, the repeated injections that would be required for effective ISCO treatment would not be feasible as much of Parcel H-3 will be inaccessible after development.	Eliminated for Parcel H-3 as source areas are located on the North Campus
Extraction Technologies (Above ground water and air treatment)	Air Sparge/SVE	Installation of air sparge wells (vertical) and soil vapor extraction wells (horizontal)	Elevated Portions of Diffuse Plume	SVE and air sparging are proven technologies for remediation of TCE in the groundwater and vadose zone, but do not effectively address the site chemicals such as 1,4-dioxane. The limited VOC concentrations in soil and shallow groundwater in Zone A on Parcel H-3 would reduce the effectiveness of these technologies. SVE and air sparging are effective in interbedded sandy soil areas where sparged or extracted vapors can be captured, but not under conditions where vapor flow is restricted such as in fine-grained soil layers, saturated soils, or confined groundwater zones similar to those found on Parcel H-3. The limited thickness of the site vadose zone and the presence of a shallow groundwater table increases the potential for short circuiting and would likely require an impermeable cover to maximize SVE/air sparging effectiveness. Furthermore, the large number of wells and associated SVE/air sparging wells that would be required is incompatible with the planned development of Parcel H-3.	Eliminated
Monitored Natural Attenuation	Monitored Natural Attenuation	Long-term monitoring to demonstrate plume stability or declining COPC concentrations	Diffuse Plume	Monitored natural attenuation (MNA) is going to be a necessary component of the remediation strategy for all zones as evaluations of the North Campus/Parcel H-3 groundwater data show that conditions are naturally supportive of anaerobic reductive dechlorination with the detections of biodegradation daughter products, and that as a result, TCE concentrations are largely stable or decreasing. MNA for 1,4 dioxane would occur by dilution and dispersive processes.	Retained
Engineering Controls	Groundwater Management Plan	Use during construction activity in Zone A to prevent groundwater contact	Diffuse Plume	Includes compilation of best management practices (BMPs) regarding saturated soil and groundwater management into a single document. The BMPs would be implemented when completing construction and/or landscaping activities within areas containing TCE concentrations exceeding human health risk levels as determined by the Parcel H-3 Human Health Risk Assessment (in progress).	Retained
	Vapor Barrier	Integration with future building construction to mitigate vapor intrusion pathway	Diffuse Plume	Need for vapor barriers in Parcel H-3 will depend on Human Health Risk Assessment (HHRA) analysis of existing vapor data. Barriers are potentially applicable to facilitate development prior to or during remedy implementation while other active remediation is ongoing. Also, potential contingency if one or more diffuse plume remediation measures fail to reach goals in a reasonable timeframe under conditions where vapors above risk thresholds are present.	To be determined based on HHRA
Institutional Controls	Deed Restrictions or Institutional Controls	Administrative	Diffuse Plume	Deed restrictions provides measures to limit human exposure after remediation is complete. Note that deed restrictions is not possible because Parcel H-3 is owned by the State of California and designated as historic tidelands.	Eliminated

Table 4
Evaluation of Remedial Alternatives
Interim Remediation for Parcel H-3

Alternative	Number of Injection Locations	Estimated Injection Duration (days)	Effectiveness	Implementability	Overall Protection of Human Health and the Environment	Estiamted Cost [1]
1 - EISB, MNA, and Engineered Controls	951	269	Moderate	Low	Moderate	$9,300,000
2 - ICSR/EISB, MNA, and Engineered Controls	437	203	Moderate-High	Moderate	Moderate-High	$7,800,000

Notes:

1. Cost estimates are Class III (expected costs range from +50% to -30% of estimates shown)

EISB - Enhanced In Situ Bioremediation

ISCR - In Situ Chemical Reduction

MNA - Monitored Natural Attenuation

Refer to Appendix A for additional assumptions and cost estimates

TABLE 5
Summary of Amendment Injection Quantities

Location	Number of Locations	Mass of ISCR Amendment (pounds)	Mass of EVO Amendment[1] (pounds)	Total Injection Volume (gallons)
PRB 1	54	37,500	63,012	161,568
PRB 2	54	37,000	63,012	161,568
PRB 3	20	13,500	47,259	121,176
PRB 4	40	27,000	23,629	60,588
North Plume	155	-	130,594	912,890
South Plume	114	-	80,947	607,507
	437	115,000	408,453	2,025,297

Notes:

[1] PRB EVO amendment amount is calculated using 5% of the injected volume

ISCR in situ chemical reduction

EVO emulsified vegetable oil

PRB permeable reactive barrier

TABLE 6
Summary of Proposed Monitoring Well Construction

Well No.	Stratigraphic Zone	Well Type[1]	Well Diameter / Construction	Estimated Total Well Depth [2] (feet bgs)	Approx. Screen Interval Depth[2] (feet bgs)
H3RTW-001-S	UB	Temporary	2" PVC	40	30-40
H3RTW-001-D	UB	Temporary	2" PVC	60	40-60
H3RTW-002	UB	Temporary	2" PVC	50	40-50
H3RTW-003-S	UB	Temporary	2" PVC	35	25- 35
H3RTW-003-D	UB	Temporary	2" PVC	65	55-65
H3RTW-004-S	UB	Temporary	2" PVC	40	30-40
H3RTW-004-D	UB	Temporary	2" PVC	65	50-65
H3RTW-005-S	UB	Temporary	2" PVC	35	25- 35
H3RTW-005-D	UB	Temporary	2" PVC	65	55-65
H3RTW-006-S	UB	Temporary	2" PVC	40	30-40
H3RTW-006-D	UB	Temporary	2" PVC	65	50-65
H3RTW-007-S	UB	Temporary	2" PVC	40	30-40
H3RTW-007-D	UB	Temporary	2" PVC	65	50-65
H3RTW-008-S	UB	Temporary	2" PVC	30	20-30
H3RTW-008-D	UB	Temporary	2" PVC	50	40-50
H3RTW-009	UB	Temporary	2" PVC	55	40-55
H3RTW-010	UB	Temporary	2" PVC	60	50-60
H3RTW-011	UB	Temporary	2" PVC	45	35-45
H3RTW-012	UB	Temporary	2" PVC	65	50-65
H3RTW-013	UB	Temporary	2" PVC	45	35-45
PRB-B1-1	UB	New	4" PVC	45	35-45
PRB-B1-2	UB	New	4" PVC	45	35-45
PRB-B1-3	UB	New	4" PVC	45	35-45
PRB-B1-4	UB	New	4" PVC	45	35-45
PRB-B1-5	UB	New	4" PVC	45	35-45
PRB-B1-6	UB	New	4" PVC	50	35-50
PRB-B1-7	UB	New	4" PVC	45	35-45
PRB-B1-8	UB	New	4" PVC	45	35-45
PRB-B1-9	UB	New	4" PVC	45	35-45
PRB-B2-1	UB	New	4" PVC	60	50-60
PRB-B2-2	UB	New	4" PVC	60	50-60
PRB-B2-3	UB	New	4" PVC	60	50-60
PRB-B3-1	UB	New	4" PVC	55	45-55
PRB-B3-2	UB	New	4" PVC	55	45-55
PRB-B3-3	UB	New	4" PVC	55	45-55
PRB-B4-1	UB	New	4" PVC	60	50-60
PRB-B4-2	UB	New	4" PVC	60	50-60
PRB-B4-3	UB	New	4" PVC	60	50-60

TABLE 6
Summary of Proposed Monitoring Well Construction

Well No.	Stratigraphic Zone	Well Type[1]	Well Diameter / Construction	Estimated Total Well Depth [2] (feet bgs)	Approx. Screen Interval Depth[2] (feet bgs)
PRB-B4-4	UB	New	4" PVC	65	50-65
PRB-B4-5	UB	New	4" PVC	65	50-65
NCW-004AR	A	Replacement	4" PVC	15	5-15
NCW-004BR	UB	Replacement	4" PVC	35	25-35
NCW-004CR	LB	Replacement	4" PVC	111	101-111
NCW-006AR	A	Replacement	4" PVC	40	30 - 40
NCW-006BR	UB	Replacement	4" PVC	69	59 - 69
NCW-006CR	LB	Replacement	4" PVC	90	80-90
NCW-021	UB	New	4" PVC	65	55-65
NCW-022	UB	New	4" PVC	40	30-40
NCW-023	UB	New	4" PVC	40	30-40
NCW-024	UB	New	4" PVC	45	35-45
NCW-025	UB	New	4" PVC	50	40-50
NCW-026	UB	New	4" PVC	55	45-55
NCW-027	UB	New	4" PVC	65	55-65
NCW-028	UB	New	4" PVC	60	50-60
NCW-029	UB	New	4" PVC	60	50-60
NCW-030	UB	New	4" PVC	60	50-60
NCW-031	UB	New	4" PVC	55	45-55
NCW-032	UB	New	4" PVC	50	40-50
NCW-033	UB	New	4" PVC	65	55-65

Notes:
[1]Temporary Wells will be destroyed prior to redevelopment
[2] Final construction of proposed wells will be determined by lithology observed in the field and data collected from temporary wells.

bgs: below ground surface
UB : Upper Zone B

TABLE 7
Summary of Target Depths and Sample Confirmation Borings

Hydropunch/Boring Point Information				Chemical Laboratory Analysis	
Well No.	Target depth [1] (ft bgs)	Proposed Soil Samples For Analytical Depths (ft bgs)	Proposed HP Sample depths (ft bgs)	**Total Organic Carbon** (SM5310D)	**TR Metals EPA 6010/6020** (Fe)
HP-B1-1	75	23-24	24-26	x	x
		43-44	44-46	x	x
		72-73	73-75	x	x
HP-B1-2	75	23-24	24-26	x	x
		37-38	38-40	x	x
		69-70	70-72	x	x
HP-B1-3	75	23-24	24-26	x	x
		37-38	38-40	x	x
		69-70	70-72	x	x
HP-B1-4	60	23-24	24-26	x	x
		41-42	42-44	x	x
		53-54	54-56	x	x
HP-B2-1	65	29-30	30-32	x	x
		48-49	49-51	x	x
		58-59	59-61	x	x
HP-B2-2	65	35-36	36-38	x	x
		52-55	53-55	x	x
HP-B2-3	65	35-36	36-38	x	x
		52-55	53-55	x	x
HP-B2-4	65	35-36	36-38	x	x
		52-55	53-55	x	x
HP-B3-1 [2]	70	45-46	46-48	x	x
		61-62	62-64	x	x
HP-B3-2 [3]	75	48-49	49-51	x	x
		67-68	68-70	x	x
HP-B4-1	65	23-24	24-26	x	x
		43-44	44-46	x	x
		63-64	64-66	x	x
HP-B4-2	65	25-26	26-28	x	x
		46-47	47-49	x	x
		63-64	64-66	x	x
HP-B4-3	65	25-26	26-28	x	x
		46-47	47-49	x	x
		63-64	64-66	x	x
HP-B4-4	65	36-37	37-39	x	x
		56-57	57-59	x	x
		63-64	64-66	x	x

Notes:
1. All borings will be continuously cored and evaluated . Actual sample depths will be determined by lithology observed in the field .
2. In addition, a groundwater sample will be collected at approximately 15 feet bgs and analyzed for 1,4-dioxane to confirm resutls at HP-68
3. In addition, a groundwater sample will be collected at approximately 70 feet bgs and analyzed for 1,4-dioxane to confirm resutls at HP-46
bgs: below ground surface

TABLE 8
Groundwater Monitoring Objectives

Well ID	MP Type	Unit	Monitoring Objective				Status During Development
			Baseline	Performance Monitoring	WDR Compliance	MNA/LTM	
H3RTW-001-S	Temporary	UB	x	x	x	--	Installed prior to Injection, then Abandoned prior to Grading
H3RTW-001-D	Temporary	UB	x	x	x	--	Installed prior to Injection, then Abandoned prior to Grading
H3RTW-002	Temporary	UB	x	x	x	--	Installed prior to Injection, then Abandoned prior to Grading
H3RTW-003-S	Temporary	UB	x	x	x	--	Installed prior to Injection, then Abandoned prior to Grading
H3RTW-003-D	Temporary	UB	x	x	x	--	Installed prior to Injection, then Abandoned prior to Grading
H3RTW-004-S	Temporary	UB	x	x	x	--	Installed prior to Injection, then Abandoned prior to Grading
H3RTW-004-D	Temporary	UB	x	x	x	--	Installed prior to Injection, then Abandoned prior to Grading
H3RTW-005-S	Temporary	UB	x	x	x	--	Installed prior to Injection, then Abandoned prior to Grading
H3RTW-005-D	Temporary	UB	x	x	x	--	Installed prior to Injection, then Abandoned prior to Grading
H3RTW-006-S	Temporary	UB	x	x	x	--	Installed prior to Injection, then Abandoned prior to Grading
H3RTW-006-D	Temporary	UB	x	x	x	--	Installed prior to Injection, then Abandoned prior to Grading
H3RTW-007-S	Temporary	UB	x	x	x	--	Installed prior to Injection, then Abandoned prior to Grading
H3RTW-007-D	Temporary	UB	x	x	x	--	Installed prior to Injection, then Abandoned prior to Grading
H3RTW-008-S	Temporary	UB	x	x	x	--	Installed prior to Injection, then Abandoned prior to Grading
H3RTW-008-D	Temporary	UB	x	x	x	--	Installed prior to Injection, then Abandoned prior to Grading
H3RTW-009	Temporary	UB	x	x	x	--	Installed prior to Injection, then Abandoned prior to Grading
H3RTW-010	Temporary	UB	x	x	x	--	Installed prior to Injection, then Abandoned prior to Grading
H3RTW-011	Temporary	UB	x	x	x	--	Installed prior to Injection, then Abandoned prior to Grading
H3RTW-012	Temporary	UB	x	x	x	--	Installed prior to Injection, then Abandoned prior to Grading
H3RTW-013	Temporary	UB	x	x	--	--	Installed prior to Injection, then Abandoned prior to Grading
NCW-001A	Existing	A	x	--	--	x	Remains
NCW-001B	Existing	UB	x	--	--	x	Remains
NCW-001C	Existing	LB	x	--	--	x	Remains
NCW-002A	Existing	A	x	--	--	x	Remains
NCW-002B	Existing	UB	x	x	x	x	Remains
NCW-002C	Existing	LB	--	--	--	--	Remains, Gauging Only
NCW-003A	Existing	A	x	--	--	x	Remains
NCW-003B	Existing	UB	x	x	x	x	Remains
NCW-003C	Existing	LB	--	--	--	--	Remains, Gauging Only
NCW-004A	Existing	A	x	--	--	--	Abandoned prior to Grading
NCW-004AR	Replacement	A	--	--	--	x	Install post-grading when access available
NCW-004B	Existing	UB	x	x	x	--	Abandoned prior to Grading
NCW-004BR	Replacement	UB	--	x	x	x	Install post-grading when access available
NCW-004C	Existing	LB	x	--	--	--	Abandoned prior to Grading
NCW-004CR	Replacement	LB	--	--	--	x	Install post-grading when access available
NCW-005A	Existing	A	x	--	--	x	Remains
NCW-005B	Existing	UB	x	x	x	x	Remains
NCW-005C	Existing	LB	x	--	--	x	Remains
NCW-006A	Existing	UB	x	x	--	--	Abandoned prior to Grading
NCW-006AR	Replacement	UB	--	x	--	x	Install post-grading when access available
NCW-006B	Existing	UB	x	x	x	--	Abandoned prior to Grading
NCW-006BR	Replacement	UB	--	x	x	x	Install post-grading when access available
NCW-006C	Existing	LB	x	x	--	--	Abandoned prior to Grading
NCW-006CR	Replacement	LB	--	--	--	x	Install post-grading when access available
NCW-007A	Existing	UB	x	x	x	x	Remains
NCW-007B	Existing	UB	--	--	--	--	Remains, Gauging only
NCW-007C	Existing	UB	--	--	--	--	Remains, Gauging only
NCW-008A	Existing	UB	x	x	x	x	Remains
NCW-008B	Existing	UB	x	x	x	x	Remains
NCW-008C	Existing	UB	--	--	--	--	Remains, Gauging only
NCW-009A	Existing	UB	x	x	x	x	Remains
NCW-009B	Existing	UB	--	--	--	--	Remains, Gauging only
NCW-009C	Existing	LB	--	--	--	--	Remains, Gauging only
NCW-016	Existing	UB	x	--	--	x	Remains
NCW-017	Existing	UB	x	--	--	x	Remains
NCW-018	Existing	UB	x	x	x	x	Remains
NCW-019	Existing	UB	x	x	x	x	Remains
NCW-020	Existing	A	x	--	--	x	Remains
PMW-124	Existing	UB	x	x	x	x	Remains
NCW-021	New	UB	--	x	x	x	Install post-grading when access available
NCW-022	New	UB	--	x	--	x	Install post-grading when access available
NCW-023	New	UB	--	x	x	x	Install post-grading when access available

TABLE 8
Groundwater Monitoring Objectives

Well ID	MP Type	Unit	Monitoring Objective				Status During Development
			Baseline	Performance Monitoring	WDR Compliance	MNA/LTM	
NCW-024	New	UB	--	x	x	x	Install post-grading when access available
NCW-025	New	UB	--	x	--	x	Install post-grading when access available
NCW-026	New	UB	--	x	--	x	Install post-grading when access available
NCW-027	New	UB	--	x	--	x	Install post-grading when access available
NCW-028	New	UB	--	x	--	x	Install post-grading when access available
NCW-029	New	UB	--	x	--	x	Install post-grading when access available
NCW-030	New	UB	--	x	x	x	Install post-grading when access available
NCW-031	New	UB	--	x	--	x	Install post-grading when access available
NCW-032	New	UB	--	x	x	x	Install post-grading when access available
NCW-033	New	UB	--	x	--	x	Install post-grading when access available
PRB-B1-1	New	UB	x	x	--	--	Installed prior to Injection, remains in place
PRB-B1-2	New	UB	x	x	--	x	Installed prior to Injection, remains in place
PRB-B1-3	New	UB	x	x	--	--	Installed prior to Injection, remains in place
PRB-B1-4	New	UB	x	x	x	--	Installed prior to Injection, remains in place
PRB-B1-5	New	UB	x	x	x	--	Installed prior to Injection, remains in place
PRB-B1-6	New	UB	x	x	x	--	Installed prior to Injection, remains in place
PRB-B1-7	New	UB	x	x	--	--	Installed prior to Injection, remains in place
PRB-B1-8	New	UB	x	x	--	x	Installed prior to Injection, remains in place
PRB-B1-9	New	UB	x	x	--	--	Installed prior to Injection, remains in place
PRB-B2-1	New	UB	--	x	x	x	Install post-grading when access available
PRB-B2-2	New	UB	--	x	x	--	Install post-grading when access available
PRB-B2-3	New	UB	--	x	x	--	Install post-grading when access available
PRB-B3-1	New	UB	--	x	x	x	Install post-grading when access available
PRB-B3-2	New	UB	--	x	x	--	Install post-grading when access available
PRB-B3-3	New	UB	--	x	x	--	Install post-grading when access available
PRB-B4-1	New	UB	--	x	x	--	Install post-grading when access available
PRB-B4-2	New	UB	--	x	x	--	Install post-grading when access available
PRB-B4-3	New	UB	--	x	x	--	Install post-grading when access available
PRB-B4-4	New	UB	--	x	x	--	Install post-grading when access available
PRB-B4-5	New	UB	--	x	x	--	Install post-grading when access available

Notes
-- not to be analyzed
X to be analyzed
HP Hydropunch
MP Monitoring Point
MNA Monitored Natural Attenuation
LB Lower Zone B
LTM Long Term Monitoring
NA Not applicable
PM Performance Monitoring
TBD To be determined based upon baseline monitoring results after well installation
UB Upper Zone B
WDR Waste Discharge Requirements

TABLE 9
Target Analytes and Monitoring Frequencies

	Monitoring Objectives	Baseline	Performance Monitoring	WDR Compliance	Monitored Natural Attenuation/ Long Term Monitoring
	Monitoring Frequency	one-time	quarterly for one year then reassess	quarterly for one year then annually	semiannually for two years then reassess
Target Analytes	VOCs -EPA 8260	X	X	X	X
	1,4-Dioxane EPA 8270 Sim	X	--	--	X
	Anions - EPA 300 (Cl, NO_3, SO_4, PO_4)	X	X	X	X
	Total Organic Carbon -SM5310D	X	X	X	X
	Dissolved Metals - EPA 6010/6020 (Fe, Mn)	X	X	--	--
	Total Recoverable Metals EPA 6010/6020 (Fe, Mn)	X	X	--	--
	Major Cations - EPA 6010/6020 (Ca ,Mg, Na, K)	X	--	X	--
	Dissolved Gases - RSK SOP175 (methane, ethane, ethene)	X	X	--	X
	Alkalinity -SM2340C	X	--	--	--
	Total Dissolved Solids - SM2540C	X	--	X	--
	Ferrous Iron - SM3500FeB or Field Test Kit	X	X	--	X
	Microbial Analysis - dHC SPP	X	X	--	--

Notes:
-- not to be analyzed
x to be analyzed
EPA Environmental Protection Agency
dHC Dehalococcoides
VOC Volitile Organic Compounds
WDR Waste Discharge Requirements

Appendix A

Feasibility Study Cost Estimates

Table A-1 - Estimate of Probable Cost, Alternative 1 - EISB and MNA for EVO Grids in Zones A, UB, and LB, Parcel H-3, Chula Vista, California

NO.	ITEM	ESTIMATED QUANTITY	UNIT (EA, LF, LS)	UNIT PRICE	# of EVENTS	ESTIMATED COST	COST SOURCE
1.00	Permits, Design, and Work Plan						
1.01	Health & Safety Plan	1	LS	$5,000	1	$5,000	Update of existing plan
1.02	Other permits, design, contract support	1	LS	$25,000	1	$25,000	Estimate from other sites
1.03	Work Plan and Report	1	LS	$20,000	1	$20,000	Update of existing plan
1.04	WDR Permitting Fee	1	LS	$7,500	1	$7,500	Estimate from other sites
	Permits, Design, and Work Plan Subtotal:					$57,500	
2.00	Full Scale Mobilization/Demobilization						
2.01	Secondary Containment	4	MONTH	$3,000	1	$12,000	3 containment - Estimate from other sites
2.02	Injection Equipment	3	LS	$2,500	1	$7,500	3 systems - estimate from other sites
2.03	Baker Tank Rental	4	MONTH	$12,000	1	$48,000	3 tanks - Estimate from other sites
2.04	Baker Tank Cleanup	3	LS	$1,000	1	$3,000	Estimate from other sites
	Full-Scale Mobilization/Demobilization Costs Subtotal:					$70,500	
3.00	Injection Activities (Per Injection Round)						
3.01	Well and Geophysical Survey	951	POINTS	$55	2	$104,990	$17,000 for one week for each survey
3.02	Direct Push Drilling - Grids Zone A	64	POINTS	$900	1	$57,600	Prior well installation - 30 ft - $30/ft, 150 ft/day
3.03	Direct Push Drilling - Grids Zone UB	887	POINTS	$2,100	1	$1,862,700	Prior well installation - 70 ft - $30/ft, 150 ft/day
3.04	Direct Push Drilling - Grids Zone LB	0	POINTS	$2,700	1	$0	Prior well installation - 90 ft - $30/ft, 150 ft/day
3.05	EVO - Grids Zone A	451	GALLONS	$12.30	1	$5,547	2019 cost quote from vendors
3.06	EVO - Grids Zone UB	79,553	GALLONS	$12.30	1	$978,502	2019 cost quote from vendors
3.07	EVO - Grids Zone LB	0	GALLONS	$12.30	1	$0	2019 cost quote from vendors
3.08	KB-1 - Grids Zone A	24	LITER	$200	1	$4,800	2018 estimate from other sites
3.09	KB-1 - Barriers Zone UB	245	LITER	$200	1	$49,000	2018 estimate from other sites
3.10	KB-1 - Grids Zone LB	0	LITER	$200	1	$0	2018 estimate from other sites
3.11	Site Set-up Supplies and Equipment	1	LS	$20,000	1	$20,000	Estimate from other sites
3.12	Injection equipment and crew	269	DAYS	$8,190	1	$2,203,110	2019 estimate from other sites
3.13	Microbial Insights	20	EACH	$400	1	$8,000	Estimate from other sites
3.14	Analytical Laboratory	95	SUITE	$500	1	$47,500	Estimate from other sites
3.15	Injection Oversight	736	DAYS	$1,100	1	$809,600	427 days drilling, 269 days injection, 40 days setup/takedown - labor days conducted over 3 months
3.16	Waste Management	25	DRUM	$250	1	$6,250	estimate from prior drilling programs
3.17	DEH Fees	951	EACH	$100	1	$95,100	Estimate from other sites
3.18	Water costs	4,720,400	GALLONS	$0.016	1	$75,526	Estimate from other sites
3.19	DEH Injection Point Completion Report	1	LS	$10,000	1	$10,000	Estimate from other sites
3.20	Direct Push and Hydro-Punch Groundwater Samples	1	LS	$16,000	1	$16,000	2 borings to assess post-injection conditions
3.21	Data Validation and Database Support	1	LS	$6,000	1	$6,000	Estimate from other sites
3.22	Reports	1	LS	$20,000	1	$20,000	Estimate from other sites
3.23	Meetings	1	LS	$25,000	1	$25,000	Estimate from other sites
	Injection Activities (Per Injection Round) Costs Subtotal:					$6,405,226	
4.00	Monitoring Costs						
4.01	Well and Geophysical Survey	43	WELL	$400	1	$17,200	$3400 for one day for each survey
4.02	Driller installation, development of Zone A monitoring wells	6	WELL	$7,500	1	$45,000	Prior well installation
4.03	Driller installation, development of Upper Zone B monitoring wells	37	WELL	$10,000	1	$370,000	Prior well installation
4.04	Direct Push and Hydro-Punch Groundwater Samples	1	LS	$16,000	1	$16,000	2019 HP Program
4.05	AECOM Oversight	52	DAY	$1,100	1	$57,200	2019 HP Program
4.06	Baseline Sampling	43	WELL	$750	1	$32,250	2019 GWM Program
	Monitoring Costs Subtotal:					$537,650	
5.00	Years 1-5 - Performance Monitoring (During Injection Program)						
5.01	Groundwater Sampling (BlaineTech)	41	WELL	$375	10	$153,750	qtrly for 1 year, semiannual for 2 yrs; annual for 2 yrs
5.02	AECOM Oversight & Coordination with lab and property owners	10	DAYS	$1,100	10	$110,000	6 field days + 4 days coordination; est other sites
5.03	Analytical Laboratory	41	SUITE	$500	10	$205,000	VOCs, metals, general minerals, 1,4-dioxane
5.04	Quarterly/Semiannual /Annual Groundwater Monitoring Reports	0	LS	$0	0	$0	Included in Task 6
5.05	Purge Water Disposal	1	LS	$4,000	10	$40,000	GWM Program
	Years 1-7 - Performance Monitoring Subtotal:					$508,750	

Table A-1 - Estimate of Probable Cost, Alternative 1 - EISB and MNA for EVO Grids in Zones A, UB, and LB, Parcel H-3, Chula Vista, California

6.00	MNA GWM (During and After Injection for 7 yrs)						
6.01	Annual Groundwater Elevation Measurements	1	EACH	$5,000	7	$35,000	GWM Program
6.02	Groundwater Sampling (BlaineTech)	14	WELL	$375	10	$52,500	semi for 3 yrs, annual for 4 yrs; sub bid
6.03	AECOM Oversight & Coordination with lab and property owners	7	DAYS	$1,100	10	$77,000	3 field days + 4 days coordination; est other sites
6.04	Analytical Laboratory	14	SUITE	$500	10	$70,000	VOCs, metals, general minerals, 1,4-dioxane
6.05	Groundwater Monitoring Reports	1	EACH	$22,000	10	$220,000	GWM Program
6.06	Purge Water Disposal	1	LS	$4,000	10	$40,000	GWM Program
6.07	Qtrly WDR Reports	1	EACH	$4,000	28	$112,000	Estimate from other sites
6.08	WDR Annual Permit Fee	1	EACH	$7,500	7	$52,500	Estimate from other sites
			MNA GWM for 7 Yrs Subtotal:			$659,000	
7.00	Closure Costs						
7.01	Abandon Groundwater Wells	43	WELL	$3,000	1	$129,000	Driller bid
7.02	Solid Waste Disposal	24	BIN	$200	1	$4,800	Waste disposal bid
7.03	Oversight	15	DAY	$1,100	1	$16,500	3 wells per day
7.04	Well Abandonment Report	1	LS	$25,000	1	$25,000	Estimate from other sites
7.05	Meetings	1	LS	$25,000	1	$25,000	Estimate from other sites
			Closure Cost Subtotal:			$200,300	
			CAPITAL COST SUBTOTAL (TASKS 1-4):			$7,070,876	
			GWM COST SUBTOTAL (TASK 5-6):			$1,167,750	
			CLOSURE COST SUBTOTAL (TASK 7):			$200,300	
			PROJECT MANAGEMENT AND ADMINISTRATION (10%)			$843,893	
			TOTAL COST:			$9,282,819	
			TOTAL COST -30% :			$6,497,973	Class III Estimate, Accuracy is +50%/-30%
			TOTAL COST +50%:			$13,924,228	Class III Estimate, Accuracy is +50%/-30%

GENERAL ASSUMPTIONS:
* No additional bench-scale testing will be required.
* Active treatment areas in Zone A and Upper Zone B were designed to treat TCE
* The injections will be spaced approximately 40 feet apart, based on 22.5-foot ROI in the pilot test.
* Costs assume that the injections would be completed in Year 1
* Performance monitoring will occur during the expected active life of the injected materials (3 to 5 years) on a quarterly basis for Year 1; semiannual for Years 2 to 3, annual for years 4 and 5.
* Annual MNA groundwater monitoring will occur during the active injection program (Year 1) and after (Years 2-7) in existing downgradient monitoring wells. Additional wells may be added to the MNA program after year 5.
* The costs do not include engineering controls (e.g., vapor barrier).
* The costs assume that DEH permit reports are completed once.
* Analytical laboratory costs include the analysis of MNA parameters, metals, 1,4-dioxane and VOCs.

Table A-2 - Estimate of Probable Cost, Alternative 2 - EISB and MNA for two EVO grids at 10 ppm and Four S-MZVI-EDS-ER UB Barriers, Parcel H-3, Chula Vista, California

NO.	ITEM	ESTIMATED QUANTITY	UNIT (EA, LF, LS)	UNIT PRICE	# of EVENTS	ESTIMATED COST	COST SOURCE
1.00	Permits, Design, and Work Plan						
1.01	Health & Safety Plan	1	LS	$5,000	1	$5,000	Update of existing plan
1.02	Other permits, design, contract support	1	LS	$25,000	1	$25,000	Estimate from other sites
1.03	Work Plan and Report	1	LS	$20,000	1	$20,000	Update of existing plan
1.04	WDR Permitting Fee	1	LS	$7,500	1	$7,500	Estimate from other sites
		Permits, Design, and Work Plan Subtotal:				$57,500	
2.00	Full Scale Mobilization/Demobilization						
2.01	Secondary Containment	4	MONTH	$2,000	1	$8,000	2 containment - Estimate from other sites
2.02	Injection Equipment	2	LS	$2,500	1	$5,000	2 systems - estimate from other sites
2.03	Baker Tank Rental	4	MONTH	$8,000	1	$32,000	2 tanks - Estimate from other sites
2.04	Baker Tank Cleanup	2	LS	$1,000	1	$2,000	Estimate from other sites
		Full-Scale Mobilization/Demobilization Costs Subtotal:				$47,000	
3.00	Injection Activities (Per Injection Round)						
3.01	Well and Geophysical Survey	437	POINTS	$55	2	$48,245	$17,000 for one week for each survey
3.02	Direct Push Drilling - Grids Zone A	0	POINTS	$900	1	$0	Prior well installation - 30 ft - $30/ft, 150 ft/day
3.03	Direct Push Drilling - Barriers Zone UB	437	POINTS	$2,100	1	$917,700	Prior well installation - 70 ft - $30/ft, 150 ft/day
3.04	Direct Push Drilling - Grids Zone LB	0	POINTS	$2,700	1	$0	Prior well installation - 90 ft - $30/ft, 150 ft/day
3.05	EVO - Grids Zone A	0	GALLONS	$12.30	1	$0	2019 cost quote from vendors
3.06	EVO - Grids Zone UB	248,668	POUNDS	$1.50	1	$373,002	ESTCP Worksheet/Vendor Estimate
3.06	S-MZVI- Barriers	115,000	POUNDS	$6.82	1	$783,840	Vendor Estimate
3.09	EVO - Barriers Zone UB	196,911	POUNDS	$1.58	1	$310,135	Vendor Estimate
3.07	EVO - Grids Zone LB	0	GALLONS	$12.30	1	$0	2019 cost quote from vendors
3.08	Inoculum - Barriers UB	588	LITER	$150	1	$88,200	2019 cost quote from vendors
3.09	KB-1 - Grids Zone UB	1,076	LITER	$150	1	$161,400	2018 estimate from other sites
3.10	KB-1 - Grids Zone LB	0	LITER	$200	1	$0	2018 estimate from other sites
3.11	Site Set-up Supplies and Equipment	1	LS	$20,000	1	$20,000	Estimate from other sites
3.12	Injection equipment and crew	204	DAYS	$8,190	1	$1,670,760	2019 estimate from other sites
3.13	Microbial Insights	20	EACH	$400	1	$8,000	Estimate from other sites
3.14	Analytical Laboratory	95	SUITE	$500	1	$47,500	Estimate from other sites
3.15	Injection Oversight	447	DAYS	$1,100	1	$491,700	204 days drilling, 203 days injection, 40 days setup/takedown - labor days conducted over 3 months
3.16	Waste Management	25	DRUM	$250	1	$6,250	estimate from prior drilling programs
3.17	DEH Fees	437	EACH	$100	1	$43,700	Estimate from other sites
3.18	Water costs	2,000,000	GALLONS	$0.016	1	$32,000	Estimate from other sites
3.19	DEH Injection Point Completion Report	1	LS	$10,000	1	$10,000	Estimate from other sites
3.20	Direct Push and Hydro-Punch Groundwater Samples	1	LS	$16,000	1	$16,000	2 borings to assess post-injection conditions
3.21	Data Validation and Database Support	1	LS	$6,000	1	$6,000	Estimate from other sites
3.22	Reports	1	LS	$20,000	1	$20,000	Estimate from other sites
3.23	Meetings	1	LS	$25,000	1	$25,000	Estimate from other sites
		Injection Activities (Per Injection Round) Costs Subtotal:				$5,079,432	
4.00	Monitoring Costs						
4.01	Well and Geophysical Survey	43	WELL	$400	1	$17,200	$3400 for one day for each survey
4.02	Driller installation, development of Zone A monitoring wells	6	WELL	$7,500	1	$45,000	Prior well installation
4.03	Driller installation, development of Upper Zone B monitoring wells	37	WELL	$10,000	1	$370,000	Prior well installation
4.04	Direct Push and Hydro-Punch Groundwater Samples	11	BOREHOLE	$4,000	1	$44,000	Prior borehole drilling
4.05	Oversight	52	DAY	$1,100	1	$57,200	2019 HP Program
4.06	Baseline Sampling	43	WELL	$750	1	$32,250	2019 GWM Program
		Monitoring Costs Subtotal:				$565,650	
5.00	Years 1-5 - Performance Monitoring (During Injection Program)						
5.01	Groundwater Sampling (BlaineTech)	41	WELL	$375	10	$153,750	qtrly for 1 year, semiannual for 2 yrs; annual for 2 yrs
5.02	AECOM Oversight & Coordination with lab and property owners	10	DAYS	$1,100	10	$110,000	6 field days + 4 days coordination; est other sites
5.03	Analytical Laboratory	41	SUITE	$500	10	$205,000	VOCs, metals, general minerals, 1,4-dioxane
5.04	Quarterly/Semiannual Groundwater Monitoring Reports	0	LS	$0	0	$0	Included in Task 6

Table A-2 - Estimate of Probable Cost, Alternative 2 - EISB and MNA for two EVO grids at 10 ppm and Four S-MZVI-EDS-ER UB Barriers, Parcel H-3, Chula Vista, California

5.05	Purge Water Disposal	1	LS	$4,000	10	$40,000	GWM Program
	Years 1-7 - Performance Monitoring Subtotal:					$508,750	
7.00	MNA GWM (During and After Injection for 7 yrs)						
7.01	Annual Groundwater Elevation Measurements	1	EACH	$5,000	7	$35,000	GWM Program
7.02	Groundwater Sampling (BlaineTech)	14	WELL	$375	10	$52,500	semi for 3 yrs, annual for 4 yrs; sub bid
7.03	AECOM Oversight & Coordination with lab and property owners	7	DAYS	$1,100	10	$77,000	3 field days + 4 days coordination; est other sites
7.04	Analytical Laboratory	14	SUITE	$500	10	$70,000	VOCs, metals, general minerals, 1,4-dioxane
7.05	Groundwater Monitoring Reports	1	EACH	$22,000	10	$220,000	GWM Program
7.06	Purge Water Disposal	1	LS	$4,000	10	$40,000	GWM Program
7.07	Qtrly WDR Reports	1	EACH	$4,000	28	$112,000	Estimate from other sites
7.08	WDR Annual Permit Fee	1	EACH	$7,500	7	$52,500	Estimate from other sites
	MNA GWM for 7 Yrs Subtotal:					$659,000	
8.00	Closure Costs						
8.01	Abandon Groundwater Wells	43	WELL	$3,000	1	$129,000	Driller bid
8.02	Solid Waste Disposal	24	BIN	$200	1	$4,800	Waste disposal bid
8.03	Oversight	15	DAY	$1,100	1	$16,500	3 wells per day
8.04	Well Abandonment Report	1	LS	$25,000	1	$25,000	Estimate from other sites
8.05	Meetings	1	LS	$25,000	1	$25,000	Estimate from other sites
	Closure Cost Subtotal:					$200,300	
	CAPITAL COST SUBTOTAL (TASKS 1-4):					$5,749,582	
	GWM COST SUBTOTAL (TASK 5-7):					$1,167,750	
	CLOSURE COST SUBTOTAL (TASK 8):					$200,300	
	PROJECT MANAGEMENT AND ADMINISTRATION (10%)					$711,763	
	TOTAL COST:					$7,829,395	
	TOTAL COST WITH -30% CONTINGENCY:					$5,480,576	
	TOTAL COST WITH +50% CONTINGENCY:					$11,744,092	

GENERAL ASSUMPTIONS:

* No additional bench-scale testing will be required.
* Active treatment areas in Zone A and Upper Zone B were designed to treat TCE
* The EVO injections will be spaced approximately 40 feet apart, based on 22.5-foot ROI in the pilot test; 15-foot ROI for S-MZVI
* Costs assume that the injections would be completed in Year 1
* Performance monitoring will occur during the expected active life of the injected materials (3 to 5 years) on a quarterly basis for Year 1; semiannual for Years 2 to 3, annual for years 4 and 5.
* Annual MNA groundwater monitoring will occur during the active injection program (Year 1) and after (Years 2-7) in existing downgradient monitoring wells. Additional wells may be added to the MNA program after year 5.
* The costs do not include engineering controls (e.g., vapor barrier).
* The costs assume that DEH permit reports are completed once.
* Analytical laboratory costs include the analysis of MNA parameters, metals, 1,4-dioxane and VOCs.

Appendix B

ISCR and EVO Amendment Calculations

REGENESIS

Project Information		
Vista Barrier		
San Diego CA		
PRB A		
Prepared For:		
Porewater		
Target Treatment Zone (TTZ) Info	**Unit**	**Value**
Barrier Length	ft	800
Top Treat Depth	ft	10.0
Bot Treat Depth	ft	55.0
Vertical Treatment Interval	ft	45.0
Treatment Zone Volume	ft^3	540,000
Treatment Zone Volume	cy	20,000
Soil Type	---	silty sand
Porosity	cm^3/cm^3	0.30
Effective Porosity	cm^3/cm^3	0.16
Treatment Zone Pore Volume	gals	1,211,844
Treatment Zone Effective Pore Volume	gals	646,317
Fraction Organic Carbon (foc)	g/g	0.003
Soil Density	g/cm^3	1.6
Soil Density	lb/ft^3	100
Soil Weight	lbs	5.4E+07
Hydraulic Conductivity	ft/day	22.0
Hydraulic Conductivity	cm/sec	7.76E-03
Hydraulic Gradient	ft/ft	0.003
GW Velocity	ft/day	0.41
GW Velocity	ft/yr	150
Contaminant Demand and Dosing	**Unit**	**Value**
Dissolved Phase Contaminant Mass	lbs	101
Sorbed Phase Contaminant Mass	lbs	197
Oxygen and Nitrate Mass	lbs	204
Total Mass Contributing to ZVI Demand	**lbs**	**503**
Mass Flux and S-MZVI Demand	**Unit**	**Value**
Groundwater Mass Flux	L/day	67,036
Stoich S-MZVI Demand	lbs	1,550
Total Mass Flux S-MZVI Requirement	lbs	35,691
Toral S-MZVI Demand	**lbs**	**37,241**
Application Dosing		
S-MZVI to be Applied	**lbs**	**37,500**

S-MZVI® Application Design Summary

PRB A		
Treatment Type	**Barrier**	**Field Mixing Ratios**
Distance Perpendicular to Flow (ft)	800	S-MZVI Concentrate per Pt (gals)
Spacing Within Rows (ft)	15	47
Number of Rows	1	Mix Water per Pt (gals)
DPT Injection Points	**53**	1452
Top Application Depth (ft bgs)	10	S-MZVI Mix Volume per Pt (gals)
Bottom Application Depth (ft bgs)	55	1499
S-MZVI to be Applied (lbs)	**37,500**	Estimated Injection Radius (ft-avg.)
S-MZVI to be Applied (gals)	2,483	3.8
S-MZVI Mix %	3.1%	Volume per Vertical Ft (gals/ft)
Volume Water (gals)	**76,979**	33
Total S-MZVI Mix Volume (gals)	79,462	

Radius based on only iron. Design ROI will be achieved by combining iron with EVO and water in a solution equal to 25% of the effective pore volume.

Prepared by: Name-Title
Date: 1/27/2020

Technical Notes/Discussion

Assumptions/Qualifications

In generating this preliminary estimate, Regenesis relied upon professional judgment and site specific information provided by others. Using this information as input, we performed calculations based upon known chemical and geologic relationships to generate an estimate of the mass of product and subsurface placement required to affect remediation of the site.

REGENESIS developed this Scope of Work in reliance upon the data and professional judgments provided by those whom completed the earlier environmental site assessment(s). The fees and charges associated with the Scope of Work were generated through REGENESIS' proprietary formulas and thus may not conform to billing guidelines, constraints or other limits on fees. REGENESIS does not seek reimbursement directly from any government agency or any governmental reimbursement fund (the "Government"). In any circumstance where REGENESIS may serve as a supplier or subcontractor to an entity which seeks reimbursement from the Government for all or part of the services performed or products provided by REGENESIS, it is the sole responsibility of the entity seeking reimbursement to ensure the Scope of Work and associated charges are in compliance with and acceptable to the Government prior to submission. When serving as a supplier or subcontractor to an entity which seeks reimbursement from the Government, REGENESIS does not knowingly present or cause to be presented any claim for payment to the Government.

REGENESIS

Project Information

Vista Barrier

San Diego CA

PRB B

Prepared For:

Porewater

Target Treatment Zone (TTZ) Info	Unit	Value
Barrier Length	ft	800
Top Treat Depth	ft	10.0
Bot Treat Depth	ft	55.0
Vertical Treatment Interval	ft	45.0
Treatment Zone Volume	ft^3	540,000
Treatment Zone Volume	cy	20,000
Soil Type	---	silty sand
Porosity	cm^3/cm^3	0.30
Effective Porosity	cm^3/cm^3	0.16
Treatment Zone Pore Volume	gals	1,211,844
Treatment Zone Effective Pore Volume	gals	646,317
Fraction Organic Carbon (foc)	g/g	0.003
Soil Density	g/cm^3	1.6
Soil Density	lb/ft^3	100
Soil Weight	lbs	5.4E+07
Hydraulic Conductivity	ft/day	22.0
Hydraulic Conductivity	cm/sec	7.76E-03
Hydraulic Gradient	ft/ft	0.003
GW Velocity	ft/day	0.41
GW Velocity	ft/yr	150
Contaminant Demand and Dosing	**Unit**	**Value**
Dissolved Phase Contaminant Mass	lbs	81
Sorbed Phase Contaminant Mass	lbs	158
Oxygen and Nitrate Mass	lbs	204
Total Mass Contributing to ZVI Demand	**lbs**	**443**
Mass Flux and S-MZVI Demand	**Unit**	**Value**
Groundwater Mass Flux	L/day	66,873
Stoich S-MZVI Demand	lbs	1,485
Total Mass Flux S-MZVI Requirement	lbs	35,025
Toral S-MZVI Demand	**lbs**	**36,511**
Application Dosing		
S-MZVI to be Applied	**lbs**	**37,000**

S-MZVI® Application Design Summary

PRB B		
Treatment Type	**Barrier**	**Field Mixing Ratios**
Distance Perpendicular to Flow (ft)	800	S-MZVI Concentrate per Pt (gals)
Spacing Within Rows (ft)	15	46
Number of Rows	1	Mix Water per Pt (gals)
DPT Injection Points	**53**	1433
Top Application Depth (ft bgs)	10	S-MZVI Mix Volume per Pt (gals)
Bottom Application Depth (ft bgs)	55	1479
S-MZVI to be Applied (lbs)	**37,000**	Estimated Injection Radius (ft-avg.)
S-MZVI to be Applied (gals)	2,450	3.7
S-MZVI Mix %	3.1%	Volume per Vertical Ft (gals/ft)
Volume Water (gals)	**75,952**	33
Total S-MZVI Mix Volume (gals)	78,403	

Radius based on only iron. Design ROI will be achieved by combining iron with EVO and water in a solution equal to 25% of the effective pore volume.

Prepared by: Name-Title

Date: 1/27/2020

Technical Notes/Discussion

Assumptions/Qualifications

In generating this preliminary estimate, Regenesis relied upon professional judgment and site specific information provided by others. Using this information as input, we performed calculations based upon known chemical and geologic relationships to generate an estimate of the mass of product and subsurface placement required to affect remediation of the site.

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REGENESIS

Project Information

Vista Barrier

San Diego CA

PRB C

Prepared For:

Porewater

Target Treatment Zone (TTZ) Info	Unit	Value
Barrier Length	ft	300
Top Treat Depth	ft	10.0
Bot Treat Depth	ft	55.0
Vertical Treatment Interval	ft	45.0
Treatment Zone Volume	ft^3	202,500
Treatment Zone Volume	cy	7,500
Soil Type	---	silty sand
Porosity	cm^3/cm^3	0.30
Effective Porosity	cm^3/cm^3	0.16
Treatment Zone Pore Volume	gals	454,442
Treatment Zone Effective Pore Volume	gals	242,369
Fraction Organic Carbon (foc)	g/g	0.003
Soil Density	g/cm^3	1.6
Soil Density	lb/ft^3	100
Soil Weight	lbs	2.0E+07
Hydraulic Conductivity	ft/day	22.0
Hydraulic Conductivity	cm/sec	7.76E-03
Hydraulic Gradient	ft/ft	0.003
GW Velocity	ft/day	0.34
GW Velocity	ft/yr	126
Contaminant Demand and Dosing	**Unit**	**Value**
Dissolved Phase Contaminant Mass	lbs	15
Sorbed Phase Contaminant Mass	lbs	30
Oxygen and Nitrate Mass	lbs	77
Total Mass Contributing to ZVI Demand	**lbs**	**121**
Mass Flux and S-MZVI Demand	**Unit**	**Value**
Groundwater Mass Flux	L/day	21,025
Stoich S-MZVI Demand	lbs	611
Total Mass Flux S-MZVI Requirement	lbs	12,778
Toral S-MZVI Demand	**lbs**	**13,388**
Application Dosing		
S-MZVI to be Applied	**lbs**	**13,500**

S-MZVI® Application Design Summary

PRB C		
Treatment Type	**Barrier**	**Field Mixing Ratios**
Distance Perpendicular to Flow (ft)	300	S-MZVI Concentrate per Pt (gals)
Spacing Within Rows (ft)	15	45
Number of Rows	1	Mix Water per Pt (gals)
DPT Injection Points	**20**	1386
Top Application Depth (ft bgs)	10	S-MZVI Mix Volume per Pt (gals)
Bottom Application Depth (ft bgs)	55	1430
S-MZVI to be Applied (lbs)	**13,500**	Estimated Injection Radius (ft-avg.)
S-MZVI to be Applied (gals)	894	3.7
S-MZVI Mix %	3.1%	Volume per Vertical Ft (gals/ft)
Volume Water (gals)	**27,712**	32
Total S-MZVI Mix Volume (gals)	28,606	

Radius based on only iron. Design ROI will be achieved by combining iron with EVO and water in a solution equal to 25% of the effective pore volume.

Prepared by: Name-Title

Date: 1/27/2020

Technical Notes/Discussion

Assumptions/Qualifications

In generating this preliminary estimate, Regenesis relied upon professional judgment and site specific information provided by others. Using this information as input, we performed calculations based upon known chemical and geologic relationships to generate an estimate of the mass of product and subsurface placement required to affect remediation of the site.

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REGENESIS

Project Information

Vista Barrier
San Diego CA
PRB D

Prepared For:
Porewater

Target Treatment Zone (TTZ) Info	Unit	Value
Barrier Length	ft	600
Top Treat Depth	ft	10.0
Bot Treat Depth	ft	55.0
Vertical Treatment Interval	ft	45.0
Treatment Zone Volume	ft^3	405,000
Treatment Zone Volume	cy	15,000
Soil Type	---	silty sand
Porosity	cm^3/cm^3	0.30
Effective Porosity	cm^3/cm^3	0.16
Treatment Zone Pore Volume	gals	908,883
Treatment Zone Effective Pore Volume	gals	484,738
Fraction Organic Carbon (foc)	g/g	0.003
Soil Density	g/cm^3	1.6
Soil Density	lb/ft^3	100
Soil Weight	lbs	4.0E+07
Hydraulic Conductivity	ft/day	22.0
Hydraulic Conductivity	cm/sec	7.76E-03
Hydraulic Gradient	ft/ft	0.003
GW Velocity	ft/day	0.34
GW Velocity	ft/yr	126
Contaminant Demand and Dosing	**Unit**	**Value**
Dissolved Phase Contaminant Mass	lbs	23
Sorbed Phase Contaminant Mass	lbs	44
Oxygen and Nitrate Mass	lbs	153
Total Mass Contributing to ZVI Demand	**lbs**	**220**
Mass Flux and S-MZVI Demand	**Unit**	**Value**
Groundwater Mass Flux	L/day	42,050
Stoich S-MZVI Demand	lbs	1,192
Total Mass Flux S-MZVI Requirement	lbs	25,337
Toral S-MZVI Demand	**lbs**	**26,529**

Application Dosing

S-MZVI to be Applied	**lbs**	**27,000**

S-MZVI® Application Design Summary

PRB D		
Treatment Type	**Barrier**	**Field Mixing Ratios**
Distance Perpendicular to Flow (ft)	600	S-MZVI Concentrate per Pt (gals)
Spacing Within Rows (ft)	15	45
Number of Rows	1	Mix Water per Pt (gals)
DPT Injection Points	**40**	1386
Top Application Depth (ft bgs)	10	S-MZVI Mix Volume per Pt (gals)
Bottom Application Depth (ft bgs)	55	1430
S-MZVI to be Applied (lbs)	**27,000**	Estimated Injection Radius (ft-avg.)
S-MZVI to be Applied (gals)	1,788	3.7
S-MZVI Mix %	3.1%	Volume per Vertical Ft (gals/ft)
Volume Water (gals)	**55,425**	32
Total S-MZVI Mix Volume (gals)	57,213	

Radius based on only iron. Design ROI will be achieved by combining iron with EVO and water in a solution equal to 25% of the effective pore volume.

Prepared by: Name-Title
Date: 1/27/2020

Technical Notes/Discussion

Assumptions/Qualifications

In generating this preliminary estimate, Regenesis relied upon professional judgment and site specific information provided by others. Using this information as input, we performed calculations based upon known chemical and geologic relationships to generate an estimate of the mass of product and subsurface placement required to affect remediation of the site.

REGENESIS developed this Scope of Work in reliance upon the data and professional judgments provided by those whom completed the earlier environmental site assessment(s). The fees and charges associated with the Scope of Work were generated through REGENESIS' proprietary formulas and thus may not conform to billing guidelines, constraints or other limits on fees. REGENESIS does not seek reimbursement directly from any government agency or any governmental reimbursement fund (the "Government"). In any circumstance where REGENESIS may serve as a supplier or subcontractor to an entity which seeks reimbursement from the Government for all or part of the services performed or products provided by REGENESIS, it is the sole responsibility of the entity seeking reimbursement to ensure the Scope of Work and associated charges are in compliance with and acceptable to the Government prior to submission. When serving as a supplier or subcontractor to an entity which seeks reimbursement from the Government, REGENESIS does not knowingly present or cause to be presented any claim for payment to the Government.

Table S.1 Input for Substrate Requirements in Hydrogen Equivalents

Site Name: UB - 10,000 ppb Grid, North Campus, Chula Vista

RETURN TO COVER PAGE

NOTE: Unshaded boxes are user input.

1. Treatment Zone Physical Dimensions	Values	Range	Units	User Notes
Width (Perpendicular to predominant groundwater flow direction)	250	1-10,000	feet	North 10,000 ppb grid
Length (Parallel to predominant groundwater flow)	930	1-1,000	feet	
Saturated Thickness	45	1-100	feet	25 to 70 ft
Treatment Zone Cross Sectional Area	11250	--	ft^2	
Treatment Zone Volume	10,462,500	--	ft^3	
Treatment Zone Total Pore Volume (total volume x total porosity)	27,398,149	--	gallons	
Treatment Zone Effective Pore Volume (total volume x effective porosity)	12,524,868	--	gallons	
Design Period of Performance	2.0	.5 to 5	year	
Design Factor (times the electron acceptor hydrogen demand)	2.0	2 to 20	unitless	
2. Treatment Zone Hydrogeologic Properties				
Total Porosity	35%	.05-50	percent	34.8% total porosity, 46% (16 ft out of 35 ft) permeable zone'
Effective Porosity	16%	.05-50	percent	16% porosity, 15% PV replacement
Average Aquifer Hydraulic Conductivity	22	.01-1000	ft/day	2019 CSM
Average Hydraulic Gradient	0.003	0.0001-0.1	ft/ft	2019 CSM
Average Groundwater Seepage Velocity through the Treatment Zone	0.41	--	ft/day	
Average Groundwater Seepage Velocity through the Treatment Zone	150.6	--	ft/yr	
Average Groundwater Discharge through the Treatment Zone	2,027,716	--	gallons/year	
Soil Bulk Density	1.6	1.4-2.0	gm/cm^3	
Soil Fraction Organic Carbon (foc)	0.04%	0.01-10	percent	
3. Native Electron Acceptors				
A. Aqueous-Phase Native Electron Acceptors				
Oxygen	1.2	0.01 to 10	mg/L	Average Zone UB concentration
Nitrate	19.00	0.1 to- 20	mg/L	Average Zone UB concentration
Sulfate	600	10 to 5,000	mg/L	Average Zone UB concentration
Carbon Dioxide (estimated as the amount of Methane produced)	0.1	0.1 to 20	mg/L	
B. Solid-Phase Native Electron Acceptors				
Manganese (IV) (estimated as the amount of Mn (II) produced)	6	0.1 to 20	mg/L	Maximum Zone UB concentration - 5.8 mg/l
Iron (III) (estimated as the amount of Fe (II) produced)	3	0.1 to 20	mg/L	Maximum Zone UB concentration - 2.5 mg/l
4. Contaminant Electron Acceptors				
Tetrachloroethene (PCE)	0.028	--	mg/L	Max within 5,000 ug/l boundary on Parcel H-3
Trichloroethene (TCE)	24.000	--	mg/L	Max within 5,000 ug/l boundary on Parcel H-3
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	6.800	--	mg/L	Max within 5,000 ug/l boundary on Parcel H-3
Vinyl Chloride (VC)	0.720	--	mg/L	Max within 5,000 ug/l boundary on Parcel H-3
Carbon Tetrachloride (CT)	0.014	--	mg/L	Max within 5,000 ug/l boundary on Parcel H-3
Trichloromethane (or chloroform) (CF)	0.000	--	mg/L	
Dichloromethane (or methylene chloride) (MC)	0.000	--	mg/L	
Chloromethane	0.000	--	mg/L	
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	--	mg/L	
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	--	mg/L	
Dichloroethane (1,1-DCA and 1,2-DCA)	0.110	--	mg/L	Max within 5,000 ug/l boundary on Parcel H-3
Chloroethane	0.000	--	mg/L	
Perchlorate	0.000	--	mg/L	
5. Aquifer Geochemistry (Optional Screening Parameters)				
A. Aqueous Geochemistry				
Oxidation-Reduction Potential (ORP)	100	-400 to +500	mV	
Temperature	20	5.0 to 30	ºC	
pH	7.0	4.0 to 10.0	su	
Alkalinity	300	10 to 1,000	mg/L	
Total Dissolved Solids (TDS, or salinity)	100	10 to 1,000	mg/L	
Specific Conductivity	200	100 to 10,000	µs/cm	
Chloride	10	10 to 10,000	mg/L	
Sulfide - Pre injection	0.0	0.1 to 100	mg/L	
Sulfide - Post injection	0.0	0.1 to 100	mg/L	
B. Aquifer Matrix				
Total Iron	10000	200 to 20,000	mg/kg	
Cation Exchange Capacity	NA	1.0 to 10	meq/100 g	
Neutralization Potential	10.0%	1.0 to 100	Percent as $CaCO_3$	

NOTES:

Table S.2 Substrate Calculations in Hydrogen Equivalents

Site Name: **UB - 10,000 ppb Grid, North Campus, Chula Vista**

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NOTE: Open cells are user input.

1. Treatment Zone Physical Dimensions	**Values**	**Range**	**Units**
Width (Perpendicular to predominant groundwater flow direction)	250	1-10,000	feet
Length (Parallel to predominant groundwater flow)	930	1-1,000	feet
Saturated Thickness	45	1-100	feet
Treatment Zone Cross Sectional Area	11250	--	ft^2
Treatment Zone Volume	10,462,500	--	ft^3
Treatment Zone Effective Pore Volume (total volume x effective porosity)	12,524,868	--	gallons
Design Period of Performance	2.0	.5 to 5	year
2. Treatment Zone Hydrogeologic Properties			
Total Porosity	0.35	.05-50	
Effective Porosity	0.16	.05-50	
Average Aquifer Hydraulic Conductivity	22	.01-1000	ft/day
Average Hydraulic Gradient	0.003	0.1-0.0001	ft/ft
Average Groundwater Seepage Velocity through the Treatment Zone	0.41	--	ft/day
Average Groundwater Seepage Velocity through the Treatment Zone	150.6	--	ft/yr
Average Groundwater Flux through the Treatment Zon 0	2,027,716	--	gallons/year
Soil Bulk Density	1.6	1.4-2.0	gm/cm^3
Soil Fraction Organic Carbon (foc)	0.0004	0.0001-0.1	

3. Initial Treatment Cell Electron-Acceptor Demand (one total pore volume)

A. Aqueous-Phase Native Electron Acceptors	Concentration (mg/L)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Oxygen	1.2	125.42	7.94	15.80	4
Nitrate (denitrification)	19.0	1985.77	12.30	161.44	5
Sulfate	600	62708.56	11.91	5265.20	8
Carbon Dioxide (estimated as the amount of methane produced)	0.1	10.45	1.99	5.25	8
			Soluble Competing Electron Acceptor Demand (lb.)	**5447.69**	

B. Solid-Phase Native Electron Acceptors (Based on manganese and iron produced)	Concentration (mg/L)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Manganese (IV) (estimated as the amount of Mn (II) produced)	5.8	802.46	27.25	29.45	2
Iron (III) (estimated as the amount of Fe (II) produced)	2.5	345.89	55.41	6.24	1
			Solid-Phase Competing Electron Acceptor Demand (lb.)	**35.69**	

C. Soluble Contaminant Electron Acceptors	Concentration (mg/L)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Tetrachloroethene (PCE)	0.028	2.93	20.57	0.14	8
Trichloroethene (TCE)	24.000	2508.34	21.73	115.43	6
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	6.800	710.70	24.05	29.55	4
Vinyl Chloride (VC)	0.720	75.25	31.00	2.43	2
Carbon Tetrachloride (CT)	0.014	1.46	19.08	0.08	8
Trichloromethane (or chloroform) (CF)	0.000	0.00	19.74	0.00	6
Dichloromethane (or methylene chloride) (MC)	0.000	0.00	21.06	0.00	4
Chloromethane	0.000	0.00	25.04	0.00	2
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	0.00	20.82	0.00	8
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	0.00	22.06	0.00	6
Dichloroethane (1,1-DCA and 1,2-DCA)	0.110	11.50	24.55	0.47	4
Chloroethane	0.000	0.00	32.00	0.00	2
Perchlorate	0.000	0.00	12.33	0.00	6
			Total Soluble Contaminant Electron Acceptor Demand (lb.)	**148.10**	

D. Sorbed Contaminant Electron Acceptors (Soil Concentration = Koc x foc x Cgw)	Koc (mL/g)	Soil Conc. (mg/kg)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Tetrachloroethene (PCE)	263	0.00	3.08	20.57	0.15	8
Trichloroethene (TCE)	107	1.03	1073.68	21.73	49.41	6
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	45	0.12	127.94	24.05	5.32	4
Vinyl Chloride (VC)	3.0	0.00	0.90	31.00	0.03	2
Carbon Tetrachloride (CT)	224	0.00	1.31	19.08	0.07	8
Trichloromethane (or chloroform) (CF)	63	0.00	0.00	19.74	0.00	6
Dichloromethane (or methylene chloride) (MC)	28	0.00	0.00	21.06	0.00	4
Chloromethane	25	0.00	0.00	25.04	0.00	2
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	117	0.00	0.00	20.82	0.00	8
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	105	0.00	0.00	22.06	0.00	6
Dichloroethane (1,1-DCA and 1,2-DCA)	30	0.00	1.38	24.55	0.06	4
Chloroethane	3	0.00	0.00	32.00	0.00	2
Perchlorate	0.0	0.00	0.00	12.33	0.00	6
				Total Sorbed Contaminant Electron Acceptor Demand (lb.)	**55.03**	

(continued)

Table S.2 Substrate Calculations in Hydrogen Equivalents

4. Treatment Cell Electron-Acceptor Flux (per year)

A. Soluble Native Electron Acceptors	Concentration (mg/L)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Oxygen	1.2	20.30	7.94	2.56	4
Nitrate (denitrification)	19.0	321.49	10.25	31.36	5
Sulfate	600	10152.21	11.91	852.41	8
Carbon Dioxide (estimated as the amount of Methane produced)	0.1	1.69	1.99	0.85	8
Total Competing Electron Acceptor Demand Flux (lb/yr)				**887.2**	

B. Soluble Contaminant Electron Acceptors	Concentration (mg/L)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Tetrachloroethene (PCE)	0.028	0.47	20.57	0.02	8
Trichloroethene (TCE)	24.000	406.09	21.73	18.69	6
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	6.800	115.06	24.05	4.78	4
Vinyl Chloride (VC)	0.720	12.18	31.00	0.39	2
Carbon Tetrachloride (CT)	0.014	0.24	19.08	0.01	8
Trichloromethane (or chloroform) (CF)	0.000	0.00	19.74	0.00	6
Dichloromethane (or methylene chloride) (MC)	0.000	0.00	21.06	0.00	4
Chloromethane	0.000	0.00	25.04	0.00	2
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	0.00	20.82	0.00	8
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	0.00	22.06	0.00	6
Dichloroethane (1,1-DCA and 1,2-DCA)	0.110	1.86	24.55	0.08	4
Chloroethane	0.000	0.00	32.00	0.00	2
Perchlorate	0.000	0.00	12.33	0.00	6
Total Soluble Contaminant Electron Acceptor Demand Flux (lb/yr)				**23.98**	

Initial Hydrogen Requirement First Year (lb)	**6,597.7**
Total Life-Cycle Hydrogen Requirement (lb)	**7,508.8**

5. Design Factors

Microbial Efficiency Uncertainty Factor	2X - 4X
Methane and Solid-Phase Electron Acceptor Uncertainty	2X - 4X
Remedial Design Factor (e.g., Substrate Leaving Reaction Zone)	1X - 3X
Design Factor	**2.0**
Total Life-Cycle Hydrogen Requirement with Design Factor (lb)	**15,017.7**

6. Acronyns and Abbreviations

^{o}C =degrees celsius
μs/cm = microsiemens per centimeter
cm/day = centimeters per day
cm/sec = centimeters per second
ft^2 = square feet
ft/day = feet per day
ft/ft = foot per foot
ft/yr = feet per year
gm/cm^3 = grams per cubic centimeter
kg of CaCO3 per mg = kilograms of calcium carbonate per milligram
lb = pounds
meq/100 g = milliequivalents per 100 grams
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
m/m = meters per meters
mV = millivolts
m/yr = meters per year
su = standard pH units
wt/wt H2 = concetration molecular hydrogen, weight per weight

Table S.3

Hydrogen Produced by Fermentation Reactions of Common Substrates

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Substrate	Molecular Formula	Substrate Molecular Weight (gm/mole)	Moles of Hydrogen Produced per Mole of Substrate	Ratio of Hydrogen Produced to Substrate (gm/gm)	Range of Moles H_2/Mole Substrate
Lactic Acid	$C_3H_6O_3$	90.1	2	0.0448	**2 to 3**
Molasses (assuming 100% sucrose)	$C_{12}H_{22}O_{11}$	342	8	0.0471	**8 to 11**
High Fructose Corn Syrup (assuming 50% fructose and 50% glucose)	$C_6H_{12}O_6$	180	4	0.0448	**4 to 6**
Ethanol	C_2H_6O	46.1	2	0.0875	**2 to 6**
Whey (assuming 100% lactose)	$C_{12}H_{22}O_{11}$	342	11	0.0648	**11**
HRC® (assumes 40% lactic acid and 40% glycerol by weight)	$C_{39}H_{56}O_{39}$	956	28	0.0590	**28**
Linoleic Acid (Soybean Oil, Corn Oil, Cotton Oil)	$C_{18}H_{32}O_2$	281	16	0.1150	**16**

Table S.4
Estimated Substrate Requirements for Hydrogen Demand in Table S.3

Design Life (years): 2

Substrate	Design Factor	Pure Substrate Mass Required to Fulfill Hydrogen Demand (pounds)	Substrate Product Required to Fulfill Hydrogen Demand (pounds)	Substrate Mass Required to Fulfill Hydrogen Demand (milligrams)	Effective Substrate Concentration (mg/L)
Lactic Acid	2.0	335,514	335,514	1.52E+11	2,425
Sodium Lactate Product (60 percent solution)	2.0	335,514	696,087	1.52E+11	2,425
Molasses (assuming 6 0	2.0	318,734	531,224	1.45E+11	2,304
HFCS (assuming 40% fructose and 40% glucose by weight)	2.0	335,588	419,485	1.52E+11	2,425
Ethanol Product (assuming 80% ethanol by weight)	2.0	171,593	214,492	7.78E+10	1,240
Whey (assuming 100% lactose)	2.0	231,604	330,862	1.05E+11	1,674
HRC® (assumes 40% lactic acid and 40% glycerol by weight)	2.0	254,338	254,338	1.15E+11	1,471
Linoleic Acid (Soybean Oil, Corn Oil, Cotton Oil)	2.0	130,594	130,594	5.92E+10	944
Commercial Vegetable Oil Emulsion Product (60% oil by weight)	2.0	130,594	217,657	5.92E+10	944

NOTES: Sodium Lactate Product
1. Assumes sodium lactate product is 60 percent sodium lactate by weight.
2. Molecular weight of sodium lactate (CH_3-CHOH-COONa) = 112.06.
3. Molecular weight of lactic Acid ($C_6H_6O_3$) = 90.08 .
4. Therefore, sodium lactate product yields 48.4 (0.60 x (90.08/112.06)) percent by weight lactic acid.
5. Weight of sodium lactate product = 11.0 pounds per gallon.
6. Pounds per gallon of lactic acid in product = 1.323 x 8.33 lb/gal H2O x 0.60 x (90.08/112.06) = 5.31 lb/gal.

NOTES: Standard HRC Product
1. Assumes HRC product is 40 percent lactic acid and 40 percent glycerol by weight.
2. HRC® weighs approximately 9.18 pounds per gallon.

NOTES: Vegetable Oil Emulsion Product
1. Assumes emulsion product is 60 percent soybean oil by weight.
2. Soybean oil is 7.8 pounds per gallon.
3. Assumes specific gravity of emulsion product is 0.96.

Table S.5 Output for Substrate Requirements in Hydrogen Equivalents

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Site Name: UB - 10,000 ppb Grid, North Campus, Chula Vista

1. Treatment Zone Physical Dimensions

	Values	Units	Values	Units
Width (perpendicular to groundwater flow)	250	feet	76	meters
Length (parallel to groundwater flow)	930	feet	283.5	meters
Saturated Thickness	45	feet	13.7	meters
Design Period of Performance	2	years	2	years

2. Treatment Zone Hydrogeologic Properties

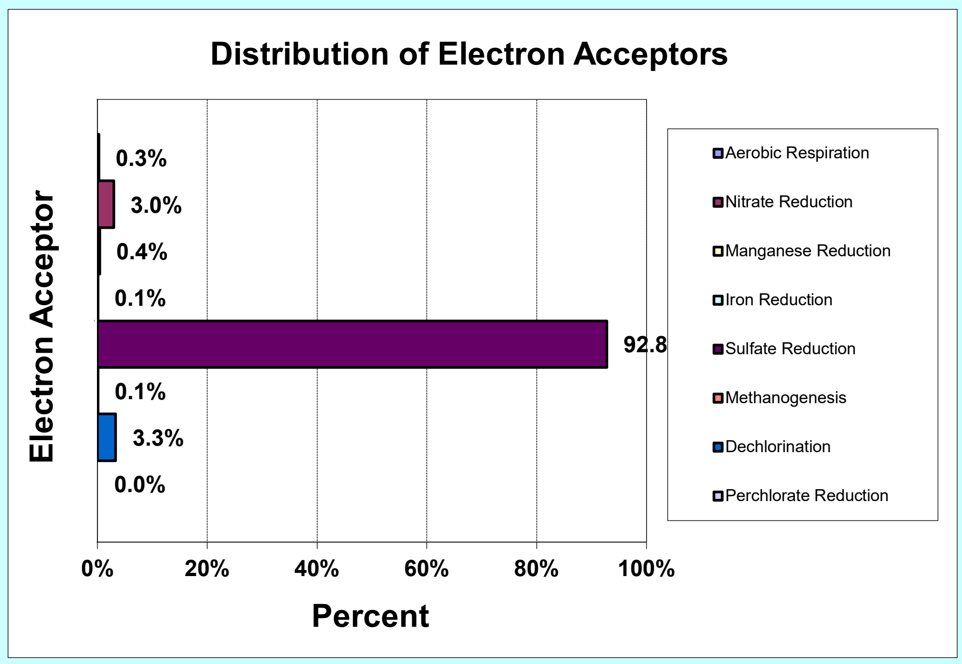
	Values	Units	Values	Units
Total Porosity	0.35	percent	0.35	percent
Effective Porosity	0.16	percent	0.16	percent
Average Aquifer Hydraulic Conductivity	22	ft/day	7.8E-03	cm/sec
Average Hydraulic Gradient	0.003	ft/ft	0.003	m/m
Average Groundwater Seepage Velocity	0.41	ft/day	1.3E+01	cm/day
Average Groundwater Seepage Velocity	151	ft/yr	45.9	m/yr
Effective Treatment Zone Pore Volume	12,524,868	gallons	47,410,458	liters
Groundwater Flux (per year)	2,027,716	gallons/year	7,675,524	liters/year
Total Groundwater Volume Treated (over entire design period)	16,580,299	gallons total	62,761,505	liters total

3. Distribution of Electron Acceptor Demand

	Percent of Total	Hydrogen Demand (lb)
Aerobic Respiration	0.3%	20.910
Nitrate Reduction	3.0%	224.174
Sulfate Reduction	92.8%	6970.024
Manganese Reduction	0.4%	29.448
Iron Reduction	0.1%	6.242
Methanogenesis	0.1%	6.953
Dechlorination	3.3%	251.084
Perchlorate Reduction	0.0%	0.000
Totals:	**100.00%**	**7508.83**

Hydrogen demand in pounds/gallon: 4.53E-04

Hydrogen demand in grams per liter: 5.43E-02



4. Substrate Equivalents: Design Factor = 2.0

Product	Quantity (lb)	Quantity (gallons)	Effective Concentration (mg/L)	Effective concentration is for total volume of groundwater treated.
1. Sodium Lactate Product	696,087	63,281	2,425	as lactic acid
2. Molasses Product	531,224	44,269	2,304	as sucrose
3. Fructose Product	419,485	37,454	2,425	as fructose
4. Ethanol Product	214,492	31,086	1,240	as ethanol
5. Sweet Dry Whey (lactose)	330,862	sold by pound	1,674	as lactose
6. HRC®	254,338	sold by pound	1,471	as 40% lactic acid/40% glycerol
7. Linoleic Acid (Soybean Oil)	130,594	16,743	944	as soybean oil
8. Emulsified Vegetable Oil	217,657	27,905	944	as soybean oil

Notes:
1. Quantity assumes product is 60% sodium lactate by weight.
2. Quantity assumes product is 60% sucrose by weight and weighs 12 pounds per gallon.
3. Quantity assumes product is 80% fructose by weight and weighs 11.2 pounds per gallon.
4. Quantity assumes product is 80% ethanol by weight and weighs 6.9 pounds per gallon.
5. Quantity assumes product is 70% lactose by weight.
6. Quantity assumes HRC® is 40% lactic acid and 40% glycerol by weight.
7. Quantity of neat soybean oil, corn oil, or canola oil.
8. Quantity assumes commercial product is 60% soybean oil by weight.

Table S.1 Input for Substrate Requirements in Hydrogen Equivalents

Site Name: UB - 10,000 ppb Grid, North Campus, Chula Vista

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NOTE: Unshaded boxes are user input.

1. Treatment Zone Physical Dimensions	Values	Range	Units	User Notes
Width (Perpendicular to predominant groundwater flow direction)	230	1-10,000	feet	South 10,000 ppb grid
Length (Parallel to predominant groundwater flow)	900	1-1,000	feet	
Saturated Thickness	45	1-100	feet	25 to 70 ft
Treatment Zone Cross Sectional Area	10350	--	ft^2	
Treatment Zone Volume	9,315,000	--	ft^3	
Treatment Zone Total Pore Volume (total volume x total porosity)	24,393,191	--	gallons	
Treatment Zone Effective Pore Volume (total volume x effective porosity)	11,151,173	--	gallons	
Design Period of Performance	2.0	.5 to 5	year	
Design Factor (times the electron acceptor hydrogen demand)	2.0	2 to 20	unitless	
2. Treatment Zone Hydrogeologic Properties				
Total Porosity	35%	.05-50	percent	34.8% total porosity, 46% (16 ft out of 35 ft) permeable zone'
Effective Porosity	16%	.05-50	percent	16% porosity, 15% PV replacement
Average Aquifer Hydraulic Conductivity	22	.01-1000	ft/day	2019 CSM
Average Hydraulic Gradient	0.003	0.0001-0.1	ft/ft	2019 CSM
Average Groundwater Seepage Velocity through the Treatment Zone	0.41	--	ft/day	
Average Groundwater Seepage Velocity through the Treatment Zone	150.6	--	ft/yr	
Average Groundwater Discharge through the Treatment Zone	1,865,498	--	gallons/year	
Soil Bulk Density	1.6	1.4-2.0	gm/cm^3	
Soil Fraction Organic Carbon (foc)	0.04%	0.01-10	percent	
3. Native Electron Acceptors				
A. Aqueous-Phase Native Electron Acceptors				
Oxygen	1.2	0.01 to 10	mg/L	Average Zone UB concentration
Nitrate	19.00	0.1 to- 20	mg/L	Average Zone UB concentration
Sulfate	400	10 to 5,000	mg/L	Average Zone UB concentration
Carbon Dioxide (estimated as the amount of Methane produced)	0.1	0.1 to 20	mg/L	
B. Solid-Phase Native Electron Acceptors				
Manganese (IV) (estimated as the amount of Mn (II) produced)	6	0.1 to 20	mg/L	Maximum Zone UB concentration - 5.8 mg/l
Iron (III) (estimated as the amount of Fe (II) produced)	3	0.1 to 20	mg/L	Maximum Zone UB concentration - 2.5 mg/l
4. Contaminant Electron Acceptors				
Tetrachloroethene (PCE)	0.028	--	mg/L	Max within 5,000 ug/l boundary on Parcel H-3
Trichloroethene (TCE)	24.000	--	mg/L	Max within 5,000 ug/l boundary on Parcel H-3
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	6.800	--	mg/L	Max within 5,000 ug/l boundary on Parcel H-3
Vinyl Chloride (VC)	0.720	--	mg/L	Max within 5,000 ug/l boundary on Parcel H-3
Carbon Tetrachloride (CT)	0.014	--	mg/L	Max within 5,000 ug/l boundary on Parcel H-3
Trichloromethane (or chloroform) (CF)	0.000	--	mg/L	
Dichloromethane (or methylene chloride) (MC)	0.000	--	mg/L	
Chloromethane	0.000	--	mg/L	
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	--	mg/L	
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	--	mg/L	
Dichloroethane (1,1-DCA and 1,2-DCA)	0.110	--	mg/L	Max within 5,000 ug/l boundary on Parcel H-3
Chloroethane	0.000	--	mg/L	
Perchlorate	0.000	--	mg/L	
5. Aquifer Geochemistry (Optional Screening Parameters)				
A. Aqueous Geochemistry				
Oxidation-Reduction Potential (ORP)	100	-400 to +500	mV	
Temperature	20	5.0 to 30	ºC	
pH	7.0	4.0 to 10.0	su	
Alkalinity	300	10 to 1,000	mg/L	
Total Dissolved Solids (TDS, or salinity)	100	10 to 1,000	mg/L	
Specific Conductivity	200	100 to 10,000	µs/cm	
Chloride	10	10 to 10,000	mg/L	
Sulfide - Pre injection	0.0	0.1 to 100	mg/L	
Sulfide - Post injection	0.0	0.1 to 100	mg/L	
B. Aquifer Matrix				
Total Iron	10000	200 to 20,000	mg/kg	
Cation Exchange Capacity	NA	1.0 to 10	meq/100 g	
Neutralization Potential	10.0%	1.0 to 100	Percent as $CaCO_3$	

NOTES:

Table S.2 Substrate Calculations in Hydrogen Equivalents

Site Name: **UB - 10,000 ppb Grid, North Campus, Chula Vista**

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NOTE: Open cells are user input.

1. Treatment Zone Physical Dimensions	**Values**	**Range**	**Units**
Width (Perpendicular to predominant groundwater flow direction)	230	1-10,000	feet
Length (Parallel to predominant groundwater flow)	900	1-1,000	feet
Saturated Thickness	45	1-100	feet
Treatment Zone Cross Sectional Area	10350	--	ft^2
Treatment Zone Volume	9,315,000	--	ft^3
Treatment Zone Effective Pore Volume (total volume x effective porosity)	11,151,173	--	gallons
Design Period of Performance	2.0	.5 to 5	year
2. Treatment Zone Hydrogeologic Properties			
Total Porosity	0.35	.05-50	
Effective Porosity	0.16	.05-50	
Average Aquifer Hydraulic Conductivity	22	.01-1000	ft/day
Average Hydraulic Gradient	0.003	0.1-0.0001	ft/ft
Average Groundwater Seepage Velocity through the Treatment Zone	0.41	--	ft/day
Average Groundwater Seepage Velocity through the Treatment Zone	150.6	--	ft/yr
Average Groundwater Flux through the Treatment Zon 0	1,865,498	--	gallons/year
Soil Bulk Density	1.6	1.4-2.0	gm/cm^3
Soil Fraction Organic Carbon (foc)	0.0004	0.0001-0.1	

3. Initial Treatment Cell Electron-Acceptor Demand (one total pore volume)

A. Aqueous-Phase Native Electron Acceptors	Concentration (mg/L)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Oxygen	1.2	111.66	7.94	14.06	4
Nitrate (denitrification)	19.0	1767.98	12.30	143.74	5
Sulfate	400	37220.56	11.91	3125.15	8
Carbon Dioxide (estimated as the amount of methane produced)	0.1	9.31	1.99	4.68	8
	Soluble Competing Electron Acceptor Demand (lb.)			**3287.63**	

B. Solid-Phase Native Electron Acceptors (Based on manganese and iron produced)	Concentration (mg/L)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Manganese (IV) (estimated as the amount of Mn (II) produced)	5.8	720.27	27.25	26.43	2
Iron (III) (estimated as the amount of Fe (II) produced)	2.5	310.46	55.41	5.60	1
	Solid-Phase Competing Electron Acceptor Demand (lb.)			**32.04**	

C. Soluble Contaminant Electron Acceptors	Concentration (mg/L)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Tetrachloroethene (PCE)	0.028	2.61	20.57	0.13	8
Trichloroethene (TCE)	24.000	2233.23	21.73	102.77	6
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	6.800	632.75	24.05	26.31	4
Vinyl Chloride (VC)	0.720	67.00	31.00	2.16	2
Carbon Tetrachloride (CT)	0.014	1.30	19.08	0.07	8
Trichloromethane (or chloroform) (CF)	0.000	0.00	19.74	0.00	6
Dichloromethane (or methylene chloride) (MC)	0.000	0.00	21.06	0.00	4
Chloromethane	0.000	0.00	25.04	0.00	2
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	0.00	20.82	0.00	8
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	0.00	22.06	0.00	6
Dichloroethane (1,1-DCA and 1,2-DCA)	0.110	10.24	24.55	0.42	4
Chloroethane	0.000	0.00	32.00	0.00	2
Perchlorate	0.000	0.00	12.33	0.00	6
	Total Soluble Contaminant Electron Acceptor Demand (lb.)			**131.85**	

D. Sorbed Contaminant Electron Acceptors (Soil Concentration = Koc x foc x Cgw)	Koc (mL/g)	Soil Conc. (mg/kg)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Tetrachloroethene (PCE)	263	0.00	2.74	20.57	0.13	8
Trichloroethene (TCE)	107	1.03	955.92	21.73	43.99	6
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	45	0.12	113.91	24.05	4.74	4
Vinyl Chloride (VC)	3.0	0.00	0.80	31.00	0.03	2
Carbon Tetrachloride (CT)	224	0.00	1.17	19.08	0.06	8
Trichloromethane (or chloroform) (CF)	63	0.00	0.00	19.74	0.00	6
Dichloromethane (or methylene chloride) (MC)	28	0.00	0.00	21.06	0.00	4
Chloromethane	25	0.00	0.00	25.04	0.00	2
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	117	0.00	0.00	20.82	0.00	8
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	105	0.00	0.00	22.06	0.00	6
Dichloroethane (1,1-DCA and 1,2-DCA)	30	0.00	1.23	24.55	0.05	4
Chloroethane	3	0.00	0.00	32.00	0.00	2
Perchlorate	0.0	0.00	0.00	12.33	0.00	6
	Total Sorbed Contaminant Electron Acceptor Demand (lb.)				**49.00**	

(continued)

Table S.2 Substrate Calculations in Hydrogen Equivalents

4. Treatment Cell Electron-Acceptor Flux (per year)

A. Soluble Native Electron Acceptors	Concentration (mg/L)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Oxygen	1.2	18.68	7.94	2.35	4
Nitrate (denitrification)	19.0	295.77	10.25	28.86	5
Sulfate	400	6226.69	11.91	522.81	8
Carbon Dioxide (estimated as the amount of Methane produced)	0.1	1.56	1.99	0.78	8
Total Competing Electron Acceptor Demand Flux (lb/yr)				**554.8**	

B. Soluble Contaminant Electron Acceptors	Concentration (mg/L)	Mass (lb)	Stoichiometric demand (wt/wt h_2)	Hydrogen Demand (lb)	Electron Equivalents per Mole
Tetrachloroethene (PCE)	0.028	0.44	20.57	0.02	8
Trichloroethene (TCE)	24.000	373.60	21.73	17.19	6
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	6.800	105.85	24.05	4.40	4
Vinyl Chloride (VC)	0.720	11.21	31.00	0.36	2
Carbon Tetrachloride (CT)	0.014	0.22	19.08	0.01	8
Trichloromethane (or chloroform) (CF)	0.000	0.00	19.74	0.00	6
Dichloromethane (or methylene chloride) (MC)	0.000	0.00	21.06	0.00	4
Chloromethane	0.000	0.00	25.04	0.00	2
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	0.00	20.82	0.00	8
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	0.00	22.06	0.00	6
Dichloroethane (1,1-DCA and 1,2-DCA)	0.110	1.71	24.55	0.07	4
Chloroethane	0.000	0.00	32.00	0.00	2
Perchlorate	0.000	0.00	12.33	0.00	6
Total Soluble Contaminant Electron Acceptor Demand Flux (lb/yr)				**22.06**	
Initial Hydrogen Requirement First Year (lb)				**4,077.4**	
Total Life-Cycle Hydrogen Requirement (lb)				**4,654.2**	

5. Design Factors

Microbial Efficiency Uncertainty Factor	2X - 4X
Methane and Solid-Phase Electron Acceptor Uncertainty	2X - 4X
Remedial Design Factor (e.g., Substrate Leaving Reaction Zone)	1X - 3X
Design Factor	**2.0**
Total Life-Cycle Hydrogen Requirement with Design Factor (lb)	**9,308.5**

6. Acronyns and Abbreviations

^{o}C =degrees celsius
µs/cm = microsiemens per centimeter
cm/day = centimeters per day
cm/sec = centimeters per second
ft^2 = square feet
ft/day = feet per day
ft/ft = foot per foot
ft/yr = feet per year
gm/cm^3 = grams per cubic centimeter
kg of CaCO3 per mg = kilograms of calcium carbonate per milligram
lb = pounds
meq/100 g = milliequivalents per 100 grams
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
m/m = meters per meters
mV = millivolts
m/yr = meters per year
su = standard pH units
wt/wt H2 = concetration molecular hydrogen, weight per weight

Table S.3

Hydrogen Produced by Fermentation Reactions of Common Substrates

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Substrate	Molecular Formula	Substrate Molecular Weight (gm/mole)	Moles of Hydrogen Produced per Mole of Substrate	Ratio of Hydrogen Produced to Substrate (gm/gm)	Range of Moles H_2/Mole Substrate
Lactic Acid	$C_3H_6O_3$	90.1	2	0.0448	**2 to 3**
Molasses (assuming 100% sucrose)	$C_{12}H_{22}O_{11}$	342	8	0.0471	**8 to 11**
High Fructose Corn Syrup (assuming 50% fructose and 50% glucose)	$C_6H_{12}O_6$	180	4	0.0448	**4 to 6**
Ethanol	C_2H_6O	46.1	2	0.0875	**2 to 6**
Whey (assuming 100% lactose)	$C_{12}H_{22}O_{11}$	342	11	0.0648	**11**
HRC® (assumes 40% lactic acid and 40% glycerol by weight)	$C_{39}H_{56}O_{39}$	956	28	0.0590	**28**
Linoleic Acid (Soybean Oil, Corn Oil, Cotton Oil)	$C_{18}H_{32}O_2$	281	16	0.1150	**16**

Table S.4

Estimated Substrate Requirements for Hydrogen Demand in Table S.3

Design Life (years): 2

Substrate	Design Factor	Pure Substrate Mass Required to Fulfill Hydrogen Demand (pounds)	Substrate Product Required to Fulfill Hydrogen Demand (pounds)	Substrate Mass Required to Fulfill Hydrogen Demand (milligrams)	Effective Substrate Concentration (mg/L)
Lactic Acid	2.0	207,963	207,963	9.43E+10	1,675
Sodium Lactate Product (60 percent solution)	2.0	207,963	431,459	9.43E+10	1,675
Molasses (assuming 6 0	2.0	197,563	329,271	8.96E+10	1,591
HFCS (assuming 40% fructose and 40% glucose by weight)	2.0	208,009	260,012	9.44E+10	1,675
Ethanol Product (assuming 80% ethanol by weight)	2.0	106,359	132,949	4.82E+10	856
Whey (assuming 100% lactose)	2.0	143,556	205,080	6.51E+10	1,156
HRC® (assumes 40% lactic acid and 40% glycerol by weight)	2.0	157,648	157,648	7.15E+10	1,016
Linoleic Acid (Soybean Oil, Corn Oil, Cotton Oil)	2.0	80,947	80,947	3.67E+10	652
Commercial Vegetable Oil Emulsion Product (60% oil by weight)	2.0	80,947	134,912	3.67E+10	652

NOTES: Sodium Lactate Product

1. Assumes sodium lactate product is 60 percent sodium lactate by weight.
2. Molecular weight of sodium lactate (CH_3-CHOH-COONa) = 112.06.
3. Molecular weight of lactic Acid ($C_6H_6O_3$) = 90.08 .
4. Therefore, sodium lactate product yields 48.4 (0.60 x (90.08/112.06)) percent by weight lactic acid.
5. Weight of sodium lactate product = 11.0 pounds per gallon.
6. Pounds per gallon of lactic acid in product = 1.323 x 8.33 lb/gal H2O x 0.60 x (90.08/112.06) = 5.31 lb/gal.

NOTES: Standard HRC Product

1. Assumes HRC product is 40 percent lactic acid and 40 percent glycerol by weight.
2. HRC® weighs approximately 9.18 pounds per gallon.

NOTES: Vegetable Oil Emulsion Product

1. Assumes emulsion product is 60 percent soybean oil by weight.
2. Soybean oil is 7.8 pounds per gallon.
3. Assumes specific gravity of emulsion product is 0.96.

Table S.5 Output for Substrate Requirements in Hydrogen Equivalents

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Site Name: **UB - 10,000 ppb Grid, North Campus, Chula Vista**

1. Treatment Zone Physical Dimensions

	Values	Units	Values	Units
Width (perpendicular to groundwater flow)	230	feet	70	meters
Length (parallel to groundwater flow)	900	feet	274.3	meters
Saturated Thickness	45	feet	13.7	meters
Design Period of Performance	2	years	2	years

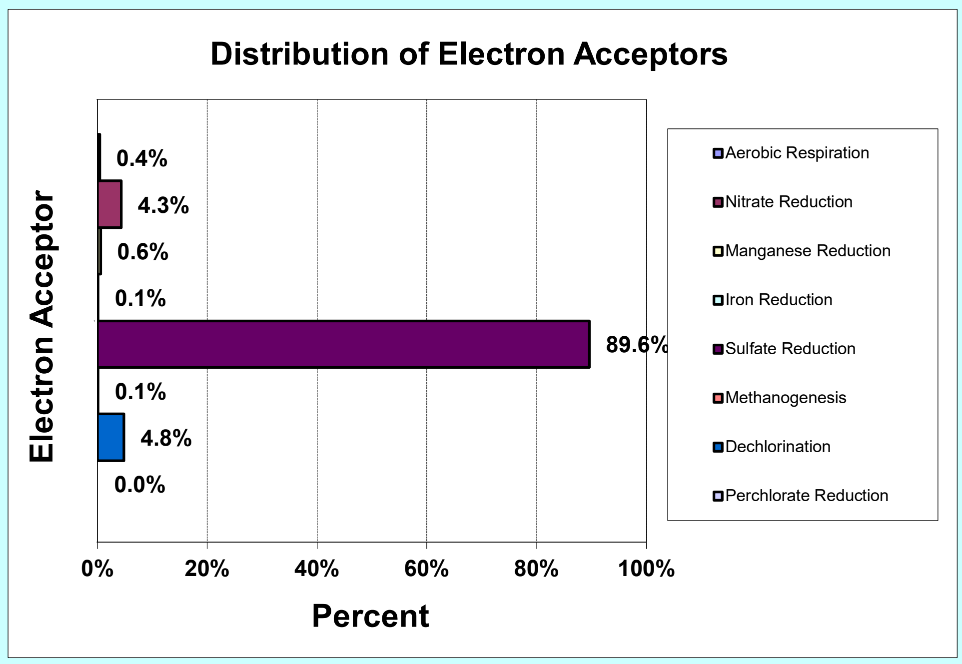
2. Treatment Zone Hydrogeologic Properties

	Values	Units	Values	Units
Total Porosity	0.35	percent	0.35	percent
Effective Porosity	0.16	percent	0.16	percent
Average Aquifer Hydraulic Conductivity	22	ft/day	7.8E-03	cm/sec
Average Hydraulic Gradient	0.003	ft/ft	0.003	m/m
Average Groundwater Seepage Velocity	0.41	ft/day	1.3E+01	cm/day
Average Groundwater Seepage Velocity	151	ft/yr	45.9	m/yr
Effective Treatment Zone Pore Volume	11,151,173	gallons	42,210,601	liters
Groundwater Flux (per year)	1,865,498	gallons/year	7,061,482	liters/year
Total Groundwater Volume Treated (over entire design period)	14,882,169	gallons total	56,333,565	liters total

3. Distribution of Electron Acceptor Demand

	Percent of Total	Hydrogen Demand (lb)
Aerobic Respiration	0.4%	18.768
Nitrate Reduction	4.3%	201.449
Sulfate Reduction	89.6%	4170.776
Manganese Reduction	0.6%	26.432
Iron Reduction	0.1%	5.603
Methanogenesis	0.1%	6.240
Dechlorination	4.8%	224.968
Perchlorate Reduction	0.0%	0.000
Totals:	**100.00%**	**4654.24**

Hydrogen demand in pounds/gallon:	3.13E-04
Hydrogen demand in grams per liter:	3.75E-02



4. Substrate Equivalents: Design Factor = 2.0

Product	Quantity (lb)	Quantity (gallons)	Effective Concentration (mg/L)	Effective concentration is for total volume of groundwater treated.
1. Sodium Lactate Product	431,459	39,224	1,675	as lactic acid
2. Molasses Product	329,271	27,439	1,591	as sucrose
3. Fructose Product	260,012	23,215	1,675	as fructose
4. Ethanol Product	132,949	19,268	856	as ethanol
5. Sweet Dry Whey (lactose)	205,080	sold by pound	1,156	as lactose
6. HRC®	157,648	sold by pound	1,016	as 40% lactic acid/40% glycerol
7. Linoleic Acid (Soybean Oil)	80,947	10,378	652	as soybean oil
8. Emulsified Vegetable Oil	134,912	17,296	652	as soybean oil

Notes:
1. Quantity assumes product is 60% sodium lactate by weight.
2. Quantity assumes product is 60% sucrose by weight and weighs 12 pounds per gallon.
3. Quantity assumes product is 80% fructose by weight and weighs 11.2 pounds per gallon.
4. Quantity assumes product is 80% ethanol by weight and weighs 6.9 pounds per gallon.
5. Quantity assumes product is 70% lactose by weight.
6. Quantity assumes HRC® is 40% lactic acid and 40% glycerol by weight.
7. Quantity of neat soybean oil, corn oil, or canola oil.
8. Quantity assumes commercial product is 60% soybean oil by weight.